

PROCEEDINGS
OF THE
AMERICAN ACADEMY
OF
ARTS AND SCIENCES.

VOL. VI.

FROM MAY, 1862, TO MAY, 1865.

SELECTED FROM THE RECORDS.

BOSTON AND CAMBRIDGE:
WELCH, BIGELOW, AND COMPANY.

1866.

PROCEEDINGS
OF THE
AMERICAN ACADEMY
OF
ARTS AND SCIENCES.

VOL. VI.

FROM MAY, 1862, TO MAY, 1865.

SELECTED FROM THE RECORDS.

BOSTON AND CAMBRIDGE:
WELCH, BIGELOW, AND COMPANY.
1866.

PROCEEDINGS
OF THE
AMERICAN ACADEMY
OF
ARTS AND SCIENCES.

SELECTED FROM THE RECORDS.

VOL. VI.

Five hundred and ninth meeting.

May 27, 1862. — ANNUAL MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read letters relative to the exchanges of the Academy.

As Secretary of the Council, he also read its Annual Report upon the changes which have occurred in the Academy during the past year, as follows: —

Five Resident Fellows, one Associate, and three Foreign Honorary Members have deceased since the last anniversary meeting.

The names now removed from our list of immediate members are those of NATHAN APPLETON, SAMUEL A. ELIOT, RICHARD SULLIVAN, CORNELIUS CONWAY FELTON, and LUTHER V. BELL.

The Hon. NATHAN APPLETON, LL. D. died at his residence, in this city, on the 14th day of July last, at nearly 82 years of age, — having been born on the 6th day of October, 1779.

He was a native of New Ipswich, in the State of New Hampshire, whither his family had removed from Old Ipswich, in the State of Massachusetts. He enjoyed the advantages of a good school education, was fitted for College, and was regularly admitted to the Freshman Class at Dartmouth, in August, 1794. But it having been decided that he should be a merchant rather than a scholar, he abandoned the collegiate course at the very outset of the term, and came at once

VOL. VI.

1

to Boston, to enter upon commercial pursuits in connection with his elder brother, the late excellent Mr. Samuel Appleton. By his perseverance, his industry, his integrity, and his force of character, he rose to the very first rank among the merchants of Boston, and identified himself with not a few of the most important enterprises of the last half-century. He was associated with the late Mr. Francis C. Lowell in the introduction of the power loom into our country, and in the establishment of the cotton manufacture in New England; and he was one of the founders of the great manufacturing city which bears the name of his associate and friend.

But his practical pursuits by no means absorbed his attention. He found time to observe, to think, to read, and to study; and he acquired the power of communicating the results of his reading and reflection in a style of remarkable condensation and clearness.

He was not without a taste for natural science, and was early accustomed to travel with a compass in his pocket, with a view to making observations as he went along. In a communication which he prepared in April, 1826, and which was published in Silliman's Journal in the following October, under the title of "Proofs that General and Powerful Currents have swept and worn the Surface of the Earth," he was among the first to call attention to those grooves and scratches on the surface of the rocks which have since given occasion to so much scientific discussion.

His studies, however, were mainly directed to subjects connected with his business pursuits. He studied the laws of currency and credit, of trade and revenue, of labor and wages; and his writings on all these topics were among the most valuable of the period in which he lived. They were generally brief articles, thrown into the columns of a newspaper from day to day, to meet the exigencies of an immediate question. But sometimes they assumed the form of elaborate essays. His "Remarks on Currency and Banking," published originally in 1841, and which reached a third edition in 1857, may be mentioned particularly, as an important contribution to the right understanding of this much-vexed subject, and one which has by no means lost its interest or its value with the occasion which called it forth. •

Mr. Appleton was frequently employed in public life, and rendered distinguished service to the Commonwealth and to the whole country, both as a member of our State Legislature, and as a member of Congress. His speeches, in the House of Representatives of the

United States, on the Tariff and the Protective System, were marked with great ingenuity and ability. He was an antagonist whom no one cared to encounter a second time. But his tastes were not for the strifes and contentions of political service, and he always returned with eagerness to the quieter walks and duties of life. He was universally respected in the community in which he lived, and will long be remembered among our most sagacious and successful merchants, and among our most enterprising, upright, and public-spirited citizens.

The HON. SAMUEL ATKINS ELIOT died at Cambridge, on the 30th day of January, 1862, in the 63d year of his age.

He was the third son of Samuel Eliot, Esq., an eminent and wealthy merchant of Boston, whose name is so honorably connected with the Professorship of the Greek Language and Literature at Harvard University.

Mr. Eliot, our late associate, was born in Boston on the 5th of March, 1798, and was graduated at Harvard in 1817. After finishing his collegiate course, he entered on the study of divinity, but soon abandoned the idea of becoming a clergyman. He did not attach himself, however, to any other profession, but devoted himself for many years to literary studies and pursuits. He was deeply interested in the public charities of Boston, and contributed several elaborate articles in relation to them to the pages of the *North American Review*. He was an ardent lover of music, and was hardly second to any one of his time in his efforts to promote the systematic culture of this delightful science in the community in which he lived.

He was an active and earnest friend to the University at Cambridge; serving it faithfully for more than ten years as its Treasurer; adding to its Library a noble collection of works on American History, at a cost of not less than five thousand dollars; and preparing and publishing (in 1848) a compendious and excellent sketch of its rise and progress.

His services were often put in requisition by his fellow-citizens in important public stations. He was associated, for a period of five successive years, with the municipal government of his native city, — for two years as one of its Aldermen, and for three years as its Mayor. In 1850 he was elected to Congress as the Representative of the Boston District, and took his seat at a moment when the ordinary responsibilities of the longest service were crowded within the little period of an expiring term. In all these positions he exhibited a

fidelity and a firmness which secured him the esteem and confidence both of those whom he represented and of those with whom he acted.

He was a gentleman of varied accomplishments, of liberal culture, of generous impulses, and of the highest moral principle. He was eminently a practical and useful man, always ready to render a service to his friends, or to the public, wherever he could find or make an opportunity. Entering upon commercial pursuits during the latter years of his life, he met the reverses which unexpectedly befell him with Christian courage and resignation; and proved himself entitled to the respect which he ever enjoyed, in adverse as well as in prosperous fortune.

Many more years of usefulness and honor might have been hoped for him by his friends, might have been anticipated by himself: but he lived long enough to secure an enviable remembrance among his fellow-men, and to lay up treasures beyond the reach of reverse or accident.

The name which comes next in order upon our annual obituary record is that of an aged associate, who, although for more than fifty years a Fellow of the Academy, so long ago retired from our meetings that his venerable form was to some of its younger members probably unknown.

The HON. RICHARD SULLIVAN was born at Saco, Maine, June 17th, 1779; was graduated at Harvard College in 1798; was admitted to the Suffolk bar in 1801; and died, December 12th, 1861. Although his life was marked by no brilliant epochs, and although he has left no monuments of fame, yet if purity and integrity, a generous culture and refined tastes, urbanity of manners and dignity of mind, gentleness in prosperity and fortitude in adversity, uniform benevolence and a consistent faith, constitute a just title to respect, his character is worthy of honorable notice, and his name is an ornament to the roll of the Academy. His services on behalf of the institutions and interests of education, literature, philanthropy, and religion were as efficient as they were unostentatious. To him, as much as to any individual, this Commonwealth is indebted for that advancement of agricultural knowledge and taste which has contributed so much to the productiveness of its soil, the embellishment of its scenery, and the comfort and enjoyment of its people. The Massachusetts General Hospital, of which he was one of the founders, — the College, his Alma-Mater, of which he was for

many years an Overseer, — the Divinity School at Cambridge, which he assisted in establishing, — besides other public associations, were largely indebted to his prudent counsels and well-directed exertions. He was a member, for several years, of the Legislature of Massachusetts and of the Executive Council. The few specimens which are remembered of his qualities as a writer and public speaker are such as to leave no doubt that, had he more extensively cultivated and exercised his gifts, he might have secured an enviable reputation for eloquence. He always enjoyed retirement, and as his strength began to fail he not reluctantly withdrew from the world, and, gracefully gathering his unspotted robe about him, calmly awaited his change.

DR. LUTHER V. BELL was born in Francestown, New Hampshire, Dec. 20, 1806. He was the second son of the Hon. Samuel Bell, who held successively the offices of Chief Justice, Governor, and U. S. Senator of his native State. At the age of sixteen Dr. Bell was graduated at Bowdoin College, and received the degree of Doctor in Medicine at Dartmouth College at the age of twenty, and later in life the honorary degree of Doctor of Laws from King's College, in Nova Scotia. He commenced the practice of medicine in his native town, where he soon acquired a distinguished reputation as a successful physician and skillful surgeon, and especially for his tact in meeting with limited means the emergencies in which country practitioners are so often called upon to act. In 1834 he received the Boylston prize for a dissertation "On the Diet best fitted for the Inhabitants of New England," and in the following year he offered for the same prize a second dissertation "On the External Exploration of Disease," a subject which was then just beginning to attract the attention of medical men in this country. The prize was justly awarded to Dr. O. W. Holmes; but the dissertations of Dr. Bell and of Dr. Haxall of Virginia were considered of unusual merit, and, through the liberality of the late Dr. Shattuck, they were printed in the publications of the Massachusetts Medical Society. Through these dissertations and his professional reputation his name became favorably known throughout New England.

The establishment of an Asylum for the Insane in New Hampshire having been proposed, Dr. Bell became one of its most earnest advocates. The inquiries of several benevolent persons revealed the existence of insanity to an extent wholly unsuspected: still the Legislature and the politicians shrank from incurring the expenditure neces-

sary to an adequate provision for so much suffering. To advance this object in question, Dr. Bell was elected a member of the Legislature; and no one contributed more largely than he, by his influence among the members and by his writings in the public journals, to insure the success of the enterprise.

While engaged in this important public service, and probably in no small degree in consequence of it, he was invited to take charge of the McLean Asylum. This appointment was highly honorable to him, as it was wholly unexpected and unsolicited on his part. He entered upon the duties of his new office early in the year 1837, and continued to perform them with unsurpassed zeal and fidelity for a period of nearly twenty years. There is but little in the routine life at such an institution which can properly be brought before the public, and yet there are but few positions where the responsibility to the public is more serious, or of a more delicate nature. The complicated details of the management of the internal affairs of an asylum for the insane, the demands, sometimes conflicting and often unreasonable, of those interested in its inmates, call for very varied and efficient executive abilities, and these he possessed in an eminent degree. Endowed with a mind naturally shrewd and observing, with wide interests and attainments in science and literature, an extensive knowledge of men and things, quiet and unostentatious, but at the same time frank, genial, and attractive, he commanded the respect and confidence of all who came in contact with him. That his administration of the affairs of the McLean Asylum were wholly successful is proved by the fact that, while under his charge, its means for usefulness were greatly increased, it attained to higher confidence in the community, and steadily advanced in reputation as the best-organized charity of its kind in the country. His published reports give abundant evidence of the success of his treatment, of the justice and truthfulness of his character, and of his intolerance of anything like exaggeration in presenting the results of his labors to the public.

While his life at the Asylum was necessarily one of comparative seclusion, he was ever ready and willing to aid in the establishment and further the objects of other institutions for the treatment of the insane. In 1845 he was commissioned by the trustees of the Butler Hospital for the Insane, in Rhode Island, to visit Europe to collect information, and to report upon the best plans for the construction, warming, ventilation, and internal economy of the newer and better-

organized Asylums. Visiting Europe for the first time, he gave his whole time to the one object of his mission, spending the day in visiting the institutions and the evenings in the preparation of his plans, giving little or no attention to other objects of interest which had so many attractions for his inquisitive and enlightened mind. The results of his labors have been presented to the public in various forms, partly in a Report to the Trustees of the Butler Hospital, partly in a discourse delivered before the members of the Massachusetts Medical Society at their annual meeting, and in a printed volume entitled "The Practical Method of Ventilating Buildings."

Dr. Bell occupied an eminent position in relation to the jurisprudence of insanity; and in our courts of justice his opinions were often called for, and were received with entire confidence and respect. The best criterion of the justness of his professional reputation is to be found in the estimation in which he was held by the members of the medical profession, who trusted in his wisdom and honored him with their highest gifts.

His last days were given to the country. In the early stage of the rebellion he offered his services, and was appointed surgeon of the 11th Massachusetts Regiment of Volunteers. At the battle of Bull Run he distinguished himself, not only by his humane devotion to the sick and wounded, foes as well as friends, but by the timely aid he secured for many of the soldiers who were wandering about after the disastrous retreat, without direction, and suffering great privations. He was subsequently made Brigade-Surgeon, and served in General Hooker's division on the Lower Potomac, where, in the active discharge of his duties, he was attacked with inflammation of the pericardium, and died in camp on the 11th of February, 1862. His life was a beneficent one; and thousands in the community whose minds have been restored from disease to health will hold him in grateful remembrance; and yet others in coming years will reap the fruits of his religious devotion to the interests of benevolence and humanity.

CORNELIUS CONWAY FELTON, LL. D. was born in West Newbury, Massachusetts, November 6, 1807. His boyhood was passed amid the privations incident to the embargo and the war with England, so ruinous to the maritime parts of the North. He was formed by nature for a scholar, and even in extreme childhood showed aptness for learning. But the means of his parents were very limited, and he was early obliged to depend wholly on himself. The boy was an epitome

of the man. He was industrious, exceedingly rapid in acquirement, always the resort of his schoolmates for aid in difficult tasks, always giving assistance with cheerfulness and alacrity, never jealous, constantly improving himself and amassing knowledge of all kinds. Moreover, his delicacy of thought and conduct in early years was as remarkable as his other traits; and these peculiarities distinguished him through his whole life.

Beside the common-school training in the districts where his father at different times resided, the entire period during which our associate obtained the advantage of schooling in the classics was just one year and nine months; and yet, when, prompted by his teacher, he sought to become a student of Harvard College, and offered himself for admission, his acquisitions, especially in the Greek and Latin classics, were far beyond the requirements of that institution, and, under the circumstances, quite astonishing. He entered College in 1823, and received the degree of A. B. in 1827, among the first scholars of his class. He was eminent in every branch of the collegiate studies: if superior to all others in any one respect, it was in the Greek language and in general philology. His mind seemed to seize a language with no painful effort in the mastery of its vocabulary or its structure, and his memory retained it with an iron grasp.

For two years after leaving College Mr. Felton was employed in teaching school in Geneseo, New York. In 1829 he was appointed Latin Tutor in Harvard College, and was transferred to the Greek Tutorship in 1830. From his first appointment at Cambridge till his death, his whole life was identified with that institution. Nearly a generation of men have witnessed his untiring devotion as a teacher. In 1832 he was made College Professor of Greek; and in 1834 he succeeded Dr. Popkin as Eliot Professor of Greek Literature, which chair he filled with signal ability until the year 1860. He mastered the whole classic literature of Greece, and became imbued with the life and genius of her people in all the epochs of her eventful history. He was familiar with the works of all the erudite Germans who have wrought in the same rich mine, and his knowledge extended to other realms of science. He also became a deep student of the English language and literature, as well as of those of most European nations.

Art also found in him a votary. He was evidently first won by its illustration of his favorite authors. But soon his mind recognized the creative genius of the artist as akin to that of the poet, and he woke

to a perception of the more abstruse meaning of Art; then he became entirely fascinated with Grecian sculpture and architecture, and we find him discoursing on the union between Greek Art, Song, and Philosophy.

He took an active part in the government of the College under four administrations, and was for several years, as Regent, the chief executive assistant of the President. But his interest was not entirely absorbed by his academic duties. He had time to give, and zealous services also, to the cause of education and science elsewhere. He was an active member of the Massachusetts Board of Education, and one of the Regents of the Smithsonian Institution. In these offices of honorable confidence his influence was widely felt.

He was a ready and an eloquent writer, always prepared to uphold the cause of truth. In the latter years of his life he established a reputation also for his interesting popular addresses on many passing occasions which could have allowed but little preparation. But his tongue and pen were never more eloquent than when employed in the interests of Greek learning, and in describing the reawaking of Hellas. He twice visited Athens. Becoming deeply impressed by the institutions of that city and the learning of its scholars, he was full of hope for the future of Greece, and through her of Eastern Europe. He enjoyed the opportunity thus allowed of knowing her men of letters and her statesmen; and, bearing with him their lasting friendship, he returned with the desire of proving to others his own convictions of the importance of modern Greek civilization and literature.

Mr. Felton's published writings have been already enumerated in print. They consist chiefly of editions of the Greek Classics, of Homer, the Agamemnon of Æschylus, the Panegyricus of Isocrates, the Clouds and the Birds of Aristophanes, and compilations for the use of advanced classical students. He also published an edition of Smith's History of Greece, adding a continuation from the Roman Conquest down to the year 1844. His contributions to Reviews on a variety of subjects are numerous and able. Besides the lectures pertaining to his professorship, he also delivered four courses upon Greek Literature before the Lowell Institute in Boston, and others at the Smithsonian Institution at Washington. Nor does this enumeration fully represent the sum of his literary labors. The trait of his childhood remained a peculiarity of his mature life. Every one who needed literary aid applied to him, and was sure to receive a willing response. The

amount of these generous contributions to the works of other writers can never be specified.

In his educational works, as well as in the class-room, President Felton always aimed to develop before his pupils the prevailing thought of the author, and to lead them to appreciate its beauty or its grandeur. If they were reading an oration of Demosthenes, he rather helped them to perceive the compact perfection of the whole design, than lingered upon the phrases. All appliances of historical, archaeological and critical knowledge were sought to help this great object. And yet the notes to his editions contain enough of minute philological remark, showing an appreciation of those points of discussion which the profoundest grammarians have dwelt on. His mirthful nature, also, — another attractive feature of his mind, — caught every merry allusion and sparkled in its light, adding a grace to the wit it reflected.

As he performed the prime duty of a teacher, that of securing his own growth while cultivating others, his teaching became continually more successful; and although his kindly nature led him to be lenient to the short-comings of his pupils, and to overlook their devices, yet the scholarly men of every class felt, as they passed under his care, that they were in contact with a master mind. Particularly has this development been apparent since his European tours in 1853-4 and in 1858. With the *Odyssey* before him, he then traced the Greek headlands and the islands of the *Ægean*, and learned to interpret the author by this commentary. *Iliad* in hand, he wandered over the Troad, and believed in Homer. At Athens he demonstrated to sceptics the identity of the *Phryx*; and, standing on its *Bema*, looked towards the *Acropolis* and recalled the thunder-words of the great orator. Wandering to the remains of the *Dionysiac Theatre*, he was in imagination present at the representation of the *Prometheus*. He climbed the steps of the *Propylæa*, and, standing amid the ruined glories of the *Parthenon*, looked down on the waters of the *Saronic*, and away to the blue heights of the *Peloponnesus*, and read the whole Grecian history in the scene. He felt too the consecration of these monuments in the holier reminiscences of *Mars Hill*. The vivid pictures thus obtained, with the wider range of thought received from intercourse with the highly cultivated minds he encountered wherever he travelled, so wrought upon his plastic nature, that he seemed almost a new man, — so fed and rekindled was his enthusiasm for his favorite studies, — so felt was his assured position among the world's scholars, and so extended were his sympathies with everything embraced in human science.

Thus developed, and thus prepared by academic life for the office, he succeeded to the presidency of the University in 1860. He entered on his new duties with the most conscientious determination to perform its functions with a sole regard to the best interests of learning and the true glory of religion. His aim was to bring about some wholesome reforms, and to foster a manly public sentiment among the students in favor of mental culture; to withdraw the young men from the pursuit of pleasure; to bring them more into sympathy with their teachers; to make the college less a resort of those who wish to amuse themselves, and more a place for vigorous training. In this endeavor he had achieved some measure of success; and, sustained by public opinion, had his life been spared, he would doubtless have seen his wishes fully realized.

Disease had already insidiously approached him before he entered on this new office, the duties of which, so unremitting and engrossing, with such painful outlay of sympathy, evidently aggravated an organic derangement of the heart. He was advised to drop his cares and give himself rest during the vacation of the College, and he went to visit his brother near Philadelphia. There, early in February last, he was seized with more aggravated symptoms, and lingered till the 26th of that month, when, surrounded by his brothers, sisters, and wife, exhibiting all the amenities of his nature, he closed his eyes on this world, to explore the glories of the next, — leaving a void here, and wherever his talents and character could be appreciated, never to be filled. His age was 54 years 3 months and 20 days.

Greece speaks by her living representative from the ranks of the Academy in the following epitaphion, in the language that our brother loved so well: —

Ἐνθάδε ἡ γῆ κατακαλύπτει
 Κορνήλιον Κόνγειον Φέλτωνα
 τοῦ ἐν Κανταβριγία Ἀρβαρδίου Συστήματος
 Πρύεδρον.
 Ἐβίω ἔτη Ν Δ, μῆνας Γ, ἡμέρας Κ.
 Μετήλλαξε μηνὸς φεβρουαρίου Κ Ϛ, ἔτους Α Ω Ξ Β.

Οἴχεται εἰς Αἶδαο, φίλων πολὺ φίλτατε Φέλτων,
 Σοῖς δ' ἐτάροις λείπεις ἄλγεα καὶ στοναχάς.
 Ἡ μὲν κλαίουσιν σοφίης ἀγαθοὶ θεράποντες,
 Ἑλλάς δ', ἣν ἐφίλεις, σὴν ἀρετὴν ποθέει.

DON ANGEL CALDERON DE LA BARCA, the only member upon the associate list whom we have lost, so far as is now known, during the past year, died, at his residence, near San Sebastian, only a day or two after our last anniversary, viz. on the 31st of May, 1861, seventy years old.

This eminent Spanish statesman, who was elected into the Academy while resident in this country, was also born upon our side of the Atlantic, in what was then the viceroyalty of Rio de la Plata. But he was early sent to Spain, and trained for the diplomatic service of his country in the Bureau for Foreign Affairs at Madrid. At different times he had different secretaryships in some of the principal countries of Europe; and, like others in similar relations to his government, suffered occasionally — once at least severely — from the factions that disturbed his country's peace. Later, he was twice Minister to the United States; his first term of service falling wholly or chiefly in the time of Mr. Van Buren, and his second in that of Mr. Tyler. During the latter, he managed with honorable ability a question which for a short time disturbed the friendly relations of Spain and the United States.

In the interval between these two missions, he was sent with large powers to Mexico, as the first authorized ambassador from Spain to her revolted colony; and by his wisdom, his moderation, and a kindness of temper which everywhere smoothed the roughest paths before him, he established between the two governments relations of amity which many statesmen had thought impossible, and which in fact did not long continue after he left the country. His success as a diplomatist who carried into all his negotiations a spirit of conciliation and forbearance, was at this time so appreciated, that, in a season of trouble and anxiety, he was summoned to Madrid, and placed at the head of the foreign affairs of the government. But, notwithstanding the great advancement such a summons implied, he left the United States with regrets, openly expressed, and with no anticipations of permanent favor in his high place, or of permanent benefit to his Queen or her people. His misgivings were soon sadly realized. The factions that divided his country became more and more exasperated. Tumults followed. The administration of which he was a member was broken up by violence; and although his well-known fidelity and honor, no less than well-known toleration, caused a marked distinction to be made between him and some of the ministers with whom he was associated, he felt at

once that he was proscribed and doomed. At first he found hospitality under the flag of one of the foreign ambassadors ; but it was soon certain that neither Madrid nor Spain could afford him the shelter his honor demanded. He therefore escaped to France, and passed a period of no common anxiety at Paris and in its neighborhood.

When calmer times came, the injustice that had been done to him was felt by all. He was therefore recalled to Madrid, and received, with other distinctions, that of a place in the Senate, whose duties he fulfilled during the few remaining years of his life with assiduity and dignity. But even in youth ambition had never been a prominent trait in his character, and now in old age he felt more than most men the unfitness of office and power. He never again sought public place, but lived retired and much respected, either at Madrid during the sessions of the Cortes, or at his villa on the shore of the Atlantic, where he died.

Señor Calderon was a person of much elegant culture, and was familiar in many languages in different departments of literature, some of which are rarely sought or valued by his countrymen. The American Academy may be thought bound to take the more careful charge of his memory, since he lived so long among us, and since his only published works, except those connected with his duties as a statesman, were, we believe, two that appeared in the United States. One of these is a graceful translation into Spanish octave verse of Wieland's *Oberon*, which appeared at New York in 1841, in a duodecimo volume of 318 pages, of which it may be not unsuitable to add, that a copy, materially corrected and improved by his own hand, is preserved by one of his friends in this city. The other is a translation into Spanish of Müller's *Universal History*, in four large octavo volumes, published at Boston in 1843,—a labor which, we believe, he undertook to gratify friends in Mexico and Cuba, who desired to read in their own language a book which he had taught them to believe was so much to be valued for the condensed instruction it affords.

The Foreign Honorary Members deceased during the past year are BIOT and BARLOW of the first Class, and SIR FRANCIS PALGRAVE of the third.

SIR FRANCIS PALGRAVE died on the 6th of July, 1861, aged seventy-two years. He was one of those men who not only do honor to their calling, but who elevate the calling itself. The strenuous application,

endless patience, and intense interest in the past, which make the province of the antiquarian so respectable, are not unnaturally associated with a microscopic and narrow vision. The discoverer, adding his own zeal and toil to the intrinsic worth of his discovery, is not in the best position fairly to compare it with things before known, and to set it in its true place. A positive benefactor to his fellow-men, he suffers in their estimation by the morbid or doting fondness with which he cherishes his benefactions. Antiquarian inquiry is often pursued as a relief from active cares, or as a refuge from the burden of unemployed ease. Idle men overvalue the light work which they really do, and busy men overvalue the by-occupation which proves their capacity to do more than one thing. But the highest kind of antiquarian research, that which follows the legal and political vestiges of the past, and seeks to unbury the cradle of a nation's institutions, is no secondary business. It tasks the energies of the best-trained mind.

This was the field in which Sir Francis Palgrave labored with marked success ; and his services have been largely used and gratefully acknowledged by writers whom it is a distinction to have pleased and aided. Though his studies often led him to explore special questions, and kept him more closely to English antiquity, his researches were not without a wider scope. One thread runs through most of them. To his mind, the ground-fact in mediæval and modern history is the perpetuation of the Roman element. The fourth empire he finds in existence still, and in possession of the area of civilization. This thought, which connects ancient, mediæval, and modern history together, though not absolutely new, and though held and enforced of late in greater or less extent by other eminent inquirers, was with him an independent and unborrowed one. Not content with linking the destiny of Continental Europe to the influence of the Eternal City, he seeks to bridge over the channel which insulates his native island, and to draw Britain also within the same great circle. In following out, sometimes it may be with excessive emphasis, this comprehensive and fruitful idea, he was able to turn to account the vast reading which had domesticated him in the Middle Ages. His familiarity with the history of art, particularly of architecture, appears in his contributions to the two leading English periodicals, in which he shakes off the dust of the Record Office, and sometimes rises to a strain of moral eloquence. Travellers in Europe have been indebted to him, often perhaps without knowing it, as the learned and able compiler of the "Handbook of North Italy."

Having published, some thirty years ago, a small volume on the History of England under the Anglo-Saxon Period, and an elaborate work on the Rise and Progress of the English Commonwealth, he was engaged in his last years on a "History of Normandy and England." Of this work he lived to complete three volumes, to publish two, and to make progress in at least a fourth. The double aspect of his subject would enable him to develop and enforce his leading ideas on early French and early English history. The published volumes deal only with the Continental side. The English portion, for which his wide and deep studies had liberally furnished him, will, it is to be hoped, soon be brought out. The work, so far as it has appeared, abounds in the fruits of learning, and bears perpetual witness to the Christian zeal and moral thoughtfulness of its author. That it has not won for him the highest honors of an historian, but has left his reputation to rest mainly, as before, on his great antiquarian labors, is owing less to a want of unity of thought (although the plan of the history has been in some respects excepted to) than of unity and proportion in the execution. He has too readily yielded to the temptation to digress and moralize; his imagination is not sufficiently curbed by severe taste; and his style is occasionally eccentric, even to the verge of the grotesque. His plea that a history is not strictly a work of art is not a full absolution for these peculiarities. But even in the part already published, as well as in many of Sir Francis's earlier essays, there is abundant life; and the reader meets with striking thoughts, sometimes expressed with great felicity and point.

In fine, if not a great historian, Sir Francis Palgrave, as a great historical antiquary, has contributed invaluable materials to history, and he has left behind him a most honorable example of fifty years of accomplished, disinterested, and devoted study.

PROFESSOR PETER BARLOW was born in Norwich, in 1776, and educated in that city. His strength of character and mathematical genius displayed themselves at an early age. In 1806 he was appointed one of the mathematical professors at the Royal Military Academy at Woolwich, which office he held forty-one years. He was the author of numerous works, among which are his well-known treatises on the "Theory of Numbers," "The Strength of Materials," and his "Essay on Magnetism." He was the author of most of the articles on subjects of practical mechanics and the useful arts in the Encyclopædia Metropolitana. These papers have been collected and

published in a separate volume. To him also we are indebted for the discovery of the cause of the weakness of hollow cylinders when exposed to an internal pressure, as in the hydrostatic press. His discovery of the means of correcting the local attraction on the compasses of ships brought him into great notoriety; he received the Copley medal, and was elected on the Council of the Royal Society. The Board of Longitude conferred upon him the rewards provided for useful nautical discoveries, and he was likewise placed by government upon several royal commissions connected with public works, while many foreign governments and societies bestowed their honors upon him. When at length, in 1847, he retired from the Royal Military Academy, the government awarded to him the full income of the professorship for the remainder of his life, in consideration of his eminent services.

In his person and manners, Mr. Barlow presented a fine specimen of the thorough, straightforward Englishman. His simple and upright character and his kind and cheerful disposition endeared him to all who were honored with his acquaintance.

JEAN BAPTISTE BIOT was born in Paris, on the 21st of April, 1774. He died on the 3d of February, 1862, at the advanced age of nearly eighty-eight years.

Having studied in the College of Louis-le-Grand, Biot joined the army. After he left the Artillery service, which he had first chosen, Biot entered the Polytechnic School, and then became Professor in the Central School at Beauvois. He was Professor of Physics in the College of France from the year 1800, and Professor of Astronomy in the Faculty of Sciences in Paris from 1809. He had been a member of the Institute since 1803, and of the Bureau of Longitudes since 1806.

Biot enjoyed the honor, which had fallen to no one besides, of belonging to three of the classes of the Institute, viz. the French Academy, the Academy of Inscriptions and Belles Lettres, and the Academy of Sciences. In the Academy of Sciences, of which he was chosen a member at the age of twenty-seven, Biot was assigned to the section of Geometry. For, although he is most familiarly known to the present generation as a physicist, he began his career as a mathematician and astronomer. No one in France was so much at home with the *Mécanique Céleste* of Laplace, all the computations in which he repeated, besides making annotations on the most difficult passages. The

session of the French Academy of Sciences on the 18th of April, 1853, was rendered memorable by the congratulations extended to Biot upon the completion, only a few days before, of his Academical Jubilee. On this occasion Thenard observed that it was a sufficiently comprehensive tribute to Biot to say simply, "that it was fortunate for science that Biot had been a member of the Academy of Sciences for 50 years."

Although the senior member of the Academy, he remained in the full exercise of his great intellectual powers to the last. During his illness, which was not alarming at first, and which continued only eight days before it suddenly terminated in death, he conversed with his associates, and responded to the profound interest taken in his restoration. When the fatal consummation of his malady, which at last manifested itself as congestion of the lungs, was announced to the Academy by Duhamel, the minds of all were too much paralyzed even for reminiscences or eulogies, much more for the election which had brought them together, and an adjournment was immediately voted.

The Institute of France made a large part of the life of Biot. He came at length to look upon himself almost as the personification of it, and spoke of its concerns with an authority conceded to no one else. He was keenly alive to its privileges and its honor. In 1837, and again in 1842, he expressed his misgivings as to the influence which the publicity of its meetings and the weekly publication of the *Comptes Rendus* would exert upon science. And again in 1858, in his *Mélanges Scientifiques et Littéraires*, he expressed the conviction that the Academy, by wishing to be known to the multitude, had lost in independence what it had gained in vulgarity. "Dieu veuille que son avenir scientifique ne se trouve pas profondément affecté par cet échange!"

Under the conviction, almost universal, that Biot was the most illustrious embodiment of the Academy and of science, the wish has been expressed that his place in the section of Geometry should remain vacant for one year, as happened after the death of Cuvier and Poisson. It was understood that Biot was ready to die as soon as the geometer Bour had ripened into a fit candidate to succeed him. On the death of Poisson, Biot inquired of the mathematician Bertrand, what young man promised the greatest future in the career of geometrical analysis. Bertrand replied, "Bour. But he will not be of full stature for three or four years." "Then," says Biot, "I need not hurry myself." Soon after, Biot asked the same question, and received the same answer again. In a short time Bour received a package contain-

ing a rare copy of the works of Lagrange, which had never been collected, but which were scattered in *Memoirs of different Academies*, with this inscription: "Presented by Lagrange to Condorcet, by Condorcet to Lacroix, by Lacroix to Biot, by Biot to Bour, by Bour to ——."

Biot's long and laborious life furnishes one of the most brilliant illustrations of science. He had no higher earthly ambition than to discover new laws of nature. He was not ambitious, as Arago, to add political distinction to his scientific honors. In 1804 he prevailed upon the Institute not to vote for Bonaparte's elevation to the throne. But his conscience as a man of science revolted at the thought of wasting any time in the distractions and jealousies inseparable from political preferment. As the Abbé Moigno adds: "L'aureole de la science lui paraissait infiniment préférable à l'aureole de la politique."

The most elaborate works of Biot are, — 1. The *Traité de Géométrie Analytique*, 1802; 2. The *Physique Expérimentale*, in 4 volumes, 1816; 3. The *Précis de Physique*, in 2 volumes, 1817; 4. The *Traité d'Astronomie*, in 3 volumes, 1805; and afterwards in 1850 in 6 volumes, with an Atlas. The latter labor he finished at the age of seventy-six, without the aid of younger collaborators. Besides these most important treatises, he published in 1803, *Essai sur l'Histoire des Sciences pendant la Révolution Française; Relation d'un Voyage fait dans le Département de l'Orne pour constater la Réalité d'un Météore observé à l'Aigle; Recherches sur les Refractions Ordinaire, &c.*, 1810; *Tables barométriques portatives*, 1811; *Recherches Expérimentale et Mathématique sur les Mouvements des Molécules de la Lumière autour de leur Centre de Gravité*, 1814; *Recherches sur Plusieurs Points de l'Astronomie Égyptienne*, 1823; *Recherches sur l'Ancienne Astronomie Chinoise*, 1840. In connection with Arago, he published *Recueil d'Observations Géodésiques, &c., &c., exécutés par Ordre du Bureau des Longitudes de France, en Espagne et en Ecosse pour déterminer la Variation de la Pesanteur*, 1821; *Instructions pratiques sur l'Observation et la Mesure des Propriétés Optiques appelées Rotations*, 1845. He also published, with Lefert, in 1856, *Commercium epistolicum J. Collins et aliorum de Analyti Promota, &c.* To these must be added the *Mélanges Scientifiques et Littéraires*, in 3 volumes, 1858.

Space would fail even to enumerate his many scattered memoirs and notices. A conception may be formed of the enormous literary and scientific labor of his life, by considering that he contributed twenty-three memoirs to the Institute, and one to the *Mémoires des Savans*.

Etrangères; that he published eight papers in the *Mémoires d'Arcueil*, twenty-three in the *Bulletin de la Société Philomatique*, fifteen in the *Annales de Chimie et de Physique*, forty in the *Comptes Rendus*, four in the *Journal des Mines*, three in the *Journal Polytechnique*, and one each in the *Connaissance des Temps* and the *Journal de Physique*. He became editor in the mathematical department of the *Journal des Savans* in 1816, and has himself contributed largely to its pages, besides furnishing many notices in the *Bibliothèque Universelle*. These numerous publications only presented the fruits of great historical or experimental research, often in new and difficult fields of investigation, ranging through every branch of Physics, Chemistry, Astronomy, and Mathematics. He welcomed, in their infancy, the new-born sciences of Electro-Magnetism and Radiant Heat, and nourished them from his own affluent resources. At one time we see him listening to the different sounds of the same organ-pipe, when filled with various gases; at another time, he is lost in the mazes of astronomical chronology, or delving among the remains of ancient Chinese science. Now he is solving a problem in the attraction of spheroids, or the tautochronous curves, or the mathematical laws of heat and sound, and then, again, he is experimenting on the gases in the bladders of fishes, or on the elastic force of vapors, or the eye-pieces of telescopes. He handles with the same delicate touch the hypothetical atoms of chemistry and the second differentials of the calculus. No speciality in the physics of our own globe eluded his vigilant eye. The figure of the planet; the variations of terrestrial gravity and terrestrial magnetism; the multitudinous phenomena of the atmosphere, its constitution, its limits, its refractions, ordinary and extraordinary; the aurora borealis; meteoric stones; — all these subjects, however incomplete they yet remain, received an additional touch at his hands. But the great thought in all his studies was given to theoretical and experimental optics. The polarization and double refraction of light, and its applications to crystallography, its use as a substitute for chemical analysis, and the production of artificial crystallization by heat, pressure, or induration, were favorite topics of study, on which he experimented largely and wrote voluminously.

The most original step which Biot took in science was when he discovered the laws of rotatory polarization, and their application to the analysis of various solutions. His labors upon this subject extend over forty years of his life, and culminated in the brilliant discovery by

Faraday of the rotatory influence imparted to glass when exposed to the constraint of electro-magnetic induction.

Biot was the ablest champion of the corpuscular theory of light. By his celebrated hypothesis of movable polarization, which fills the entire volume of the Academy of Science for 1812, he succeeded in giving a formal explanation to the phenomena of depolarization, and of delaying for a time the triumph of the theory of undulations. In this attempt he had the sympathy of Laplace and other prominent mathematicians, who found the speculations of Biot more congenial to their habits of thought than the theory of Fresnel. Arago, however, soon entered the lists against Biot, and the discussion was carried on with such bitterness that these distinguished physicists, once intimately associated, were wholly estranged from each other. It may be inferred, however, from the reflections of Biot in his *Mélanges Scientifiques et Littéraires*, that, if he were not altogether converted to the undulatory theory of light, he could not but acknowledge the wonderful felicity with which Fresnel had adapted it to the various classes of phenomena with which experimental research had enriched the domains of optics within the present century.

Few salient points present themselves in the even tenor of a life dedicated to the unostentatious pursuit of science, as that of Biot was *par excellence*. In 1804, Biot and Gay-Lussac proposed to ascend in a balloon to the higher region of the air, to measure the force of terrestrial magnetism at great elevations, and to experiment upon the chemical and electrical properties of the atmosphere at different heights. By the instigation of Berthollet and Laplace, aided by the influence of the great chemist Chaptal, who was then Minister of the Interior, the government gave its support to the projected enterprise; and one of the celebrated balloons of Conté, which had survived Napoleon's campaign in Egypt, was intrusted to the scientific explorers, and the artist who constructed it was placed at their disposal to prepare it for its peaceful ascent. Supplied with a full complement of barometers, thermometers, hygrometers, electrometer, and instruments for measuring the magnetic force and dip, as well as frogs, insects, and birds for galvanic experiments, the scientific voyagers embarked in their aerial car on the 23d of August, 1804. They began their experiments at the altitude of 6,500 feet, and continued them up to the altitude of 13,000 feet, and with a success commensurate with their wishes. The last part of the excursion, and especially the landing which they

made, was so difficult, and even dangerous, that, according to the statement of Sir John Leslie, "Biot, though a man of activity, and not deficient in personal courage, was so much overpowered by the alarms of their descent, as to lose for the time the entire possession of himself."

At the commencement of 1806, Biot, accompanied by Arago, who was then only twenty years old, left Paris to resume the measurement of a degree of the meridian in Spain, which had been interrupted by the death of Mechain. Arago, in his autobiography, has given a detailed account of the labors and dangers of this scientific enterprise, all of which, however, were successfully surmounted. To connect by triangulation the station at Deserto de las Palmas with Campvey, in the island of Iviça, required intense signals, capable of being seen nearly one hundred miles. Long and anxiously they awaited a favorable opportunity, encamped on inhospitable mountains, with no society but the winds and the eagles.

In the summer of 1817, Biot was despatched to the Orkney and the Shetland Islands, to correct some disputed astronomical observations; and thus at both extremes he was instrumental in fixing that ideal meridian line which the finger of geometry has drawn from Unst, in the North Sea, to Formentera, in the Mediterranean, — the sure foundation of the French metre and the decimal system which the Revolution introduced into science. Biot returned to Paris by the way of the Greenwich Observatory, and there, in presence of Arago and Humboldt, he experimented on the vibrations of the pendulum, Humboldt being willing, as Biot expressed it, to lay aside for the moment the multitude of his other talents, for the sake of being only a good observer.

During his two months' residence in the Shetland Islands, Biot lost no opportunity of observing the aurora, and studying for himself the problematic phenomena associated with it. And wherever he travelled, he was not unmindful of the climate, or the manners and customs of the people nurtured under it. His good sense and calm philosophy are often forcibly impressed on his writings. The Italians pity the French, because doomed to live under a cold sky; the French are contented, but pity the English; the English are contented, but pity the Scotch; the Scotch are contented, but pity the Shetlanders; the Shetlanders are contented, but they, too, pity the Icelanders, for the inhospitable climate of their Northern home. "*La vérité est que dans tous les climats du monde, l'homme peut vivre avec une somme de bon heur à peu près égale, s'il porte avec lui les vertus sociales et les ressources du commerce et de la civilization.*"

Biot was the last survivor of a brilliant epoch in science, made illustrious by the names of Laplace, Gay-Lussac, Cuvier, De Candolle, and Humboldt, and inspired to extraordinary activity by the spirit of the early French Revolution. Biot outlived, by ten years, his own son, Edward Constant Biot, who shared his father's love of knowledge, rose to be a member of the Academy of Inscriptions and Belles-Lettres in 1847, was distinguished by his acquaintance with the Chinese language, and is well known as an explorer among the archives of Chinese science.

When Biot and Arago were engaged in Spain upon their geodetic survey, they had an interview with the Archbishop of Valencia, to seek his protection. Biot left the hall of reception without kissing the hand of the Franciscan. Before Arago could escape, he was recalled, and obliged to submit, though he confesses he had in mind chiefly the success of the survey, and the beautiful stone in the ring of the Archbishop, which he coveted for optical experiments. Late in life Biot returned to the bosom of the mother Church, and received the rite of confirmation at the hands of his own grandson.

Biot was able to accomplish a task, enormous even when measured by his long life, in consequence of his simple and regular habits of study and recreation, and the singleness of heart with which he dedicated himself to the study of physical laws. He wrote during the forenoon, took a walk at noon, read in the afternoon, and passed the evening in the family circle.

The *Journal des Debats* of February 6 has the following notice: "To-day, at noon, the obsequies of Biot were attended by a crowd of the colleagues and friends of the deceased. The entire Faculty of Sciences, and many members of the Institute, assisted at the sad ceremony. The Normal and Polytechnic Schools were represented by large deputations. The funeral *cortège* was directed from the Church of St. Etienne-du-Mont to the cemetery Montparnasse, where many eulogies were pronounced. Viennet spoke in the name of the French Academy, Bertrand for the Academy of Sciences, M. de Rougé for the Academy of Inscriptions and Belles-Lettres, Serret for the College of France, and Puiseux for the Faculty of Sciences.

A distinguished French *litterateur* writes to one of our own academicians: "Biot's death is a sad loss to our scientific world. He was the only member of the Institute who belonged to the consular period. His successor as *Doyen de Reception*, the astronomer Matthieu, dates

from 1817. A whole age, a whole scientific world, has been borne with Biot to the tomb. Even the venerable Académie Française is tottering to the grave. That old institution is dying by mere *impossibilité de vivre*. The other classes of the Institute have more sap, and can last much longer."

The accessions to the ranks of the Academy since the last report consist of 11 Resident and 4 Associate Fellows, and of 4 Foreign Honorary Members. Four of the newly chosen Resident Fellows are assigned to the first Class, two to the second Class, and five to the third Class.

Two of the Associates are of the first, one of the second, and one of the third Class.

Of the Foreign Honorary Members recently chosen, Sir William Fairbairn fills the vacancy left by the death of Robert Stephenson in Class I. Section 4. Captain Duperrey, in Class II. Section 1, supplies the place of the late Professor Tiedemann of the third Section. Professor Bekker takes the place of Professor Thiersch in Class III. Section 2; and Professor Trendelenburg, in the first Section, that of Bunsen.

The following schedule indicates the numbers of the actual members of the Academy, and their distribution in the Classes and Sections:—

CLASS I.			CLASS II.			CLASS III.		
<i>Resident Fellows.</i>								
Sect. 1	12		Sect. 1	10		Sect. 1	12	
" 2	7		" 2	8		" 2	18	
" 3	16		" 3	14		" 3	13	
" 4	14		" 4	16		" 4	15	
	<u>49</u>			<u>48</u>			<u>58</u>	155
<i>Associate Fellows.</i>								
Sect. 1	9		Sect. 1	10		Sect. 1	3	
" 2	10		" 2	7		" 2	8	
" 3	11		" 3	9		" 3	2	
" 4	7		" 4	5		" 4	3	
	<u>37</u>			<u>31</u>			<u>16</u>	84

Foreign Honorary Members.

Sect. 1	8	Sect. 1	8	Sect. 1	5	
" 2	6	" 2	7	" 2	8	
" 3	7	" 3	8	" 3	3	
" 4	4	" 4	5	" 4	2	
	<u>25</u>		<u>28</u>		<u>18</u>	71
						<u>310</u>

The annual report of the Treasurer, attested by the Auditors, was read, accepted, and ordered to be entered in full upon the records.

The annual report of the Library Committee, and that of the Committee on Publications, were read, accepted, and ordered to be placed on file.

On motion of the Treasurer, appropriations for the various expenditures of the Academy, the same as for the preceding year, were voted.

On motion of the Vice-President, a committee was appointed to examine and report on the administration of the Rumford fund; and, on motion of Dr. M. Wyman, the same committee was instructed to consider the expediency of collecting and reprinting Count Rumford's published writings, at the expense of the Academy.

The President, Professors Parsons and Gray, and Messrs. Emerson and J. A. Lowell, were chosen to serve on this committee.

Professor Hubert A. Newton, of Yale College, was elected an Associate Fellow, in the Mathematical Section.

The annual election was held, and the following officers were chosen for the ensuing year: —

JACOB BIGELOW, *President.*

DANIEL TREADWELL, *Vice-President.*

ASA GRAY, *Corresponding Secretary.*

SAMUEL L. ABBOT, *Recording Secretary.*

JOSIAH P. COOKE, *Librarian.*

EDWARD WIGGLESWORTH, *Treasurer.*

Council.

J. I. BOWDITCH,	}	of Class I.
JOSEPH LOVERING,		
E. N. HORSFORD,		
LOUIS AGASSIZ,	}	of Class II.
JEFFRIES WYMAN,		
J. B. S. JACKSON,		
JAMES WALKER,	}	of Class III.
HENRY W. TORREY,		
ROBERT C. WINTHROP,		

The several Standing Committees, upon the nomination of the President, were appointed as follows:—

Rumford Committee.

EBEN N. HORSFORD,	JOSEPH LOVERING,
DANIEL TREADWELL,	MORRILL WYMAN,
JOSEPH WINLOCK.	

Committee of Publication.

JOSEPH LOVERING,	JEFFRIES WYMAN,
CHARLES BECK.	

Committee on the Library.

AUGUSTUS A. GOULD,	WILLIAM B. ROGERS,
GEORGE P. BOND.	

Committee to Audit the Treasurer's Accounts.

THOMAS T. BOUVÉ,	CHARLES E. WARE.
------------------	------------------

Committee of Finance.

JACOB BIGELOW,	}	<i>ex officio, by statute.</i>
EDWARD WIGGLESWORTH,		
J. INGERSOLL BOWDITCH, <i>by appointment.</i>		

On motion of the Vice-President, the meeting was adjourned

to Tuesday, the first day of June next; then to consider and act upon the question of awarding the Rumford Premium.

Five hundred and tenth meeting.

June 1, 1862. — ADJOURNED ANNUAL MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read letters relative to the exchanges of the Academy.

Professor Child presented a paper, entitled, "Observations on the Language of Chaucer."

On motion of Professor Horsford, seconded by Professor Treadwell, it was voted: —

"That the Rumford Premium be awarded to John B. Ericsson, for his improvements in the management of heat, particularly as shown in his Caloric Engine of 1858."

On motion of Dr. Morrill Wyman, the following resolution was passed, viz.: —

"That the sum of six hundred dollars be paid by the Academy, from the Rumford Fund, to Philander Shaw, of the city of Boston, to be expended by him in experiments or investigations relative to air-engines; said experiments and investigations being, in the opinion of the Academy, such as will facilitate and encourage the making of a discovery or improvement which may merit the Rumford Premium or Medals."

Five hundred and eleventh meeting.

August 12, 1862. — STATUTE MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read letters received relating to the exchanges of the Academy. Also a letter from the Secretary of the American Oriental Society, conveying the thanks of that Society to the American Academy for the use of its hall.

The President, from the Committee appointed at the Annual Meeting on the 27th of May last, read the following Report.

The Committee appointed to examine and report upon the administration of the Rumford Fund, respectfully report :—

The following letter was addressed by Count Rumford to Hon. John Adams, July 12, 1796 :—

“ SIR :—

“ Desirous of contributing efficaciously to the advancement of a branch of science which has long employed my attention, and which appears to me to be of the highest importance to mankind ; and wishing at the same time to leave a lasting testimony of my respect for the American Academy of Arts and Sciences,—I take the liberty to request that the Academy would do me the honor to accept of Five Thousand Dollars three per cent stock in the funds of the United States of North America, which stock I have actually purchased, and which I beg leave to transfer to the Fellows of the Academy, to the end that the interest of the same may be by them, and by their successors, received from time to time, forever, and the amount of the same applied, and given once every second year, as a premium to the author of the most important discovery, or useful improvement, which shall be made and published by printing, or in any way made known to the public, in any part of the continent of America, or in any of the American islands, during the preceding two years, on Heat or on Light ; the preference always being given to such discoveries as shall, in the opinion of the Academy, tend most to promote the good of mankind.

“ With regard to the formalities to be observed by the Academy in their decisions upon the comparative merits of those discoveries, which, in the opinion of the Academy, may entitle their authors to be considered as competitors for this biennial premium, the Academy will be pleased to adopt such regulations as they in their wisdom may judge to be proper and necessary. But in regard to the form in which this premium is conferred, I take the liberty to request that it may always be given in two medals, struck in the same die ; the one of gold, and the other of silver, and of such dimensions that both of them together may be just equal in intrinsic value to the amount of the interest of the aforesaid Five Thousand Dollars stock during two years ;—that is to say, that they may together be of the value of Three Hundred Dollars.

“ The Academy will be pleased to order such device or inscription to be engraved on the die they shall cause to be prepared for striking these medals, as they may judge proper.

“ If during any term of two years, reckoning from the last adjudication, or from the last period for the adjudication of this premium by the Academy,

no new discovery or improvement should be made, in any part of America, relative to either of the subjects in question (Heat or Light), which in the opinion of the Academy shall be of sufficient importance to deserve this premium, in that case it is my desire that the premium may not be given, but that the value of it may be reserved, and, being laid out in the purchase of additional stock in the American funds, may be employed to augment the capital of this premium; and that the interest of the sums by which the capital may from time to time be so augmented may regularly be given in *money*, with the two medals, and as an addition to the original premium, at each succeeding adjudication of it. And it is further my particular request, that those additions to the value of the premium arising from the occasional non-adjudications, may be suffered to increase without limitation.

"With the highest respect for the American Academy of Arts and Sciences, and the most earnest wishes for their success in their labors for the good of mankind, I have the honor to be, with much esteem and regard,

Sir,

Your most obedient, humble servant,

RUMFORD."

"*London, July 12, 1796.*"

The stocks mentioned in this letter were received by the Academy in 1797. In 1831 a Bill in Equity was brought before the Supreme Judicial Court of Massachusetts, praying relief in the matter of the Rumford Fund; and thereupon the following decree was made by that Court:—

DECREE. — *Supreme Judicial Court, March Term, 1832.*

In Equity } The American Academy of Arts and Sciences, Complainants,
between } The President and Fellows of Harvard College, Defendants.

"The cause coming to be heard upon the Bill and answer, by agreement of the parties, — the substance of the plaintiff's Bill appeared to be that

"Benjamin, Count Rumford, in his lifetime, made a donation to the plaintiffs of five thousand dollars in the three per cent stocks of the United States, as a testimony of his respect for the American Academy of Arts and Sciences, and for the purpose of promoting by premiums, to be adjudged biennially by them, for the making of such discoveries relating to light and heat, as should, in the opinion of the plaintiffs, tend most to promote the good of mankind, and which should be made and published in the American continent or islands within the two years next preceding the awarding of such premium, and directing the surplus income and accumulation of said fund to be invested in the stock of the United States, and the income thereof added to the said premiums. But it is alleged that the mode of awarding said premiums pointed out by the donor cannot usefully, nor without defeating the general

intent of the donor, be strictly complied with; and that in consequence thereof no premiums have been yet awarded, but the said fund has, by the addition of the income thereof, accumulated to the sum of nearly twenty thousand dollars; and the income thereof for two years has become too large for a proper premium for such discovery; and that the same cannot longer be conveniently invested in the stocks of the United States. Therefore, that the plaintiffs may be authorized to dispose of the surplus income of said funds in other modes adapted to promote the general intent of the donor, and to invest said fund in more convenient securities.

"Whereeto, the defendants, by answer, admit the material facts set forth in the Bill, but allege that, as residuary legatees of said Benjamin, Count Rumford, they are entitled to have paid over to them, for the use of the Rumford Professorship, founded by said Count Rumford, at said University, any portion of said fund, and of the accumulation and interest thereof, which cannot be applied in the hands of the complainants to the execution of the general intent of said donor.

"The cause having been argued by counsel, and fully considered, it appears to the Court that the complainants have not done any act, or neglected or omitted to do anything, whereby they have forfeited, waived, or renounced the said donation, and that the President and Fellows of Harvard College have no right, as residuary legatees of Count Rumford, or otherwise, to claim the same, or any part thereof. It further appears that the said donation was made to the American Academy for a general purpose of charity, that, namely, of promoting a useful branch of science for the benefit of mankind; that the Academy accepted the same, upon the terms stated, and for the purposes contemplated by said donation, and are now under obligation to carry the general intent of the donor into effect, as far as it is practicable to do so. It further appears, that, in consequence of the impediments set forth in the Bill, it is impracticable for the Academy to carry the general charitable intent of the donor into effect in the exact and precise mode specified by him; but, considering the general and primary intent of Count Rumford to have been to awaken and stimulate the ingenuity, and encourage the researches and experiments of individuals on the continent or the islands of America to make important discoveries or useful improvements upon the subjects of Light and Heat, and to cause them speedily to be published for the good of mankind, it does appear to the Court, that it is quite practicable for the Academy to accomplish and carry into effect the general charitable intent and purpose of Count Rumford by some slight alterations in the mode particularly prescribed by him for carrying the same into effect. It also appears to the Court that it would tend to promote the general charitable intent of the donor to allow the complainants to invest the principal of the said fund in some safe and productive securities other than the stocks of the United States.

"Whereupon, it was ordered by the Court that the matter be referred to one of the Masters in Chancery, to report a scheme for carrying into effect the general charitable intent and purpose of the donor, conformably to the prayer of the plaintiffs' Bill; and now John B. Davis, Esquire, one of the Masters in Chancery for the County of Suffolk, having reported a scheme in pursuance of said order, which, being heard and considered by the Court, and the same appearing reasonable and conformable to the general intent of the donor, is accepted; and it is therefore by the Court ordered, adjudged, and decreed, for the reasons set forth in the Bill, that the complainants be, and they are by the authority of this Court, empowered to make from the income of said fund, as it now exists, at any annual meeting of the Academy, (instead of biennially, as directed by the said Benjamin, Count Rumford,) award of a gold and silver medal, being together of the intrinsic value of three hundred dollars, as a premium to the author of any important discovery or useful improvement on Light or on Heat, which shall have been made and published by printing, or in any way made known to the public, in any part of the continent of America, or any of the American islands, preference being always given to such discoveries as shall, in the opinion of the Academy, tend most to promote the good of mankind; and to add to such medals as a further reward and premium for such discovery or improvement, if the complainants see fit so to do, a sum of money not exceeding three hundred dollars.

"And it is further ordered, adjudged, and decreed, that the complainants may appropriate from time to time, as the same can advantageously be done, the residue of the income of said fund hereafter to be received, and not so as aforesaid awarded in premiums, to the purchase of such books and papers and philosophical apparatus, (to be the property of said Academy,) and in making such publications, or procuring such lectures, experiments, or investigations, as shall in their opinion best facilitate and encourage the making of discoveries and improvements, which may merit the premiums so as aforesaid to be by them awarded. And the books, papers, and apparatus so purchased shall be used, and such lectures, experiments, and investigations be delivered and made, either in the said Academy or elsewhere, as the complainants shall think best adapted to promote such discoveries and improvements as aforesaid; and either by the Rumford Professor of Harvard University, or by any other person or persons, as to the complainants shall from time to time seem best.

"And it is further ordered, adjudged, and decreed, that the said fund, or any part thereof, may be from time to time invested by the said complainants either in notes, stocks, or debts of the United States, or of the Commonwealth of Massachusetts, or of the City of Boston, or in stock of the Bank of the United States, or of any bank in this Commonwealth, or in notes or bonds secured by pledge of any of said stocks, or by mortgage of real estate in this Commonwealth, or may be deposited in trust, and on interest, with the Massachusetts Hospital Life Insurance Company."

In 1832 the Rumford Fund amounted to . . . \$ 23,159.00
 From that time to the present, the receipts of the Rum-
 ford Fund have amounted to . . . 41,574.00

These receipts have been used or expended by the Academy in
 the following manner :—

Addition to the Rumford Fund	3,158.00
(making the sum now \$ 26,317).	
Award to Dr. Hare	600.00
For the publications of the Academy	19,642.00
For the purchase of books	12,646.00
For the Telescope and other astronomical apparatus in the Observatory at Cambridge	3,776.00
For Rain Gauges, and sundry expenses, by Dr. Hale, for experiments and investigations relating to the fall of rain	1,697.00
	<u>\$ 41,519.00</u>

The above items were taken from the returns made to this Com-
 mittee by the treasurer of the Academy. In relation to them he says :
 “The following statements are substantially correct. To make the
 figures strictly accurate would take more time than I can spare.”

The Committee offer these facts for the consideration of the Acad-
 emy; and with them the following suggestions in respect to the future
 administration of the trust :—

1. The statutes require that “the Treasurer shall keep a separate
 account of the income and appropriation of the Rumford Fund, and
 report the same annually.” (Chap. vi. 3.) Your Committee recom-
 mend that all payments and expenditures from the income of this fund
 shall be by separate and distinct appropriations.

2. It appears that the Rumford Committee was formerly charged
 with a general supervision of this trust, and that they directed or
 superintended the expenditure of such appropriations as from time to
 time were made from the income of the fund, for instruments, books,
 &c. Your Committee recommend that this supervision be resumed,
 and that books, instruments, apparatus, &c. shall be paid for from the
 Rumford Fund only on the certificate of the Rumford Committee, that
 such books, &c. will “in their opinion best facilitate and encourage the
 making of discoveries and improvements which may merit the Rum-
 ford medals.”

3. Your Committee further recommend that the Rumford Committee be instructed to use all proper means to make the Rumford Fund constantly active and useful, so as to carry out the donor's intention in the manner defined by the decree of the Supreme Court in 1832, not only by recognizing just claims to the Rumford medals, but also by instituting or encouraging investigations and experiments, which may lead to discoveries or improvements worthy of the Rumford Premium.

4. As one method of effectively promoting the foregoing objects, your Committee would recommend the occasional offering of a premium for the solving of important specific questions concerning the properties or uses of light and heat. Questions or problems of this kind from time to time arise, of much scientific and practical consequence, the settlement of which may probably be expedited by the opportune direction of attention to them by the Academy; and to those who best solve such problems the medal may perhaps not unfrequently be given.

5. Your Committee recommend that such books or publications as the Academy possess, or may hereafter acquire, by means of the income of the Rumford Fund, should be so marked or ticketed as permanently to indicate the fact that they were so acquired.

Should the Academy adopt the foregoing propositions, a few alterations of its laws will be necessary to give them effect. A draught of the alterations proposed is appended to this Report.

Another subject referred to this Committee was the expediency of republishing the complete works of Count Rumford at the expense of the Academy. The Committee have inquired of a bookselling house the probable expense of an edition of five hundred copies of the three volumes of Count Rumford's works now in the Academy's library, and find that it would be about \$1,800. Although they would desire to pay any practicable mark of respect to the memory of Count Rumford, both for his services to science and his relations to this Academy, yet they feel obliged to report that it is inexpedient for the Academy, in the present state of its funds, to incur so considerable an expense.

JACOB BIGELOW,
THEOPHILUS PARSONS,
J. A. LOWELL,
ASA GRAY,
GEO. B. EMERSON.

Draught of the proposed alterations of the Statutes and Standing Votes.

Statutes: in Chapter IV., amend Section 3, so that it shall read as follows:—

3. *The Rumford Committee, of five Fellows, to be chosen by ballot; who shall consider and report on all applications and claims for the Rumford Premium, also on all appropriations from the income of the Rumford Fund, and generally see to the due and proper execution of this trust.*

Chapter VII., as an additional section:—

1^a. *To all books in the library procured from the income of the Rumford Fund, the Librarian shall cause a stamp or label to be affixed, expressing the fact that they were so procured.*

Additional Standing Vote proposed:—

Books, publications, or apparatus shall be procured from the income of the Rumford Fund only on the certificate of the Rumford Committee that they, in their opinion, will best facilitate and encourage the making of discoveries and improvements which may merit the Rumford Premium.

The above Report was accepted, and ordered to be printed and distributed to the Fellows previous to the ensuing adjourned meeting, to be held on the 9th of September, proximo.

Also the draught of the proposed Statutes and Standing Vote was recommitted, with instructions to the Committee to report a draught of such other alterations of the Statutes as, in view of the adoption of those now proposed, may appear to them necessary or expedient.

On motion of the Treasurer, it was ordered, that the letter of the executors of the late Samuel Appleton's will, which accompanied their donation of ten thousand dollars to the Academy in November, 1854, be recorded, and that a reference be made from the record of the donation to the record of the letter.

The meeting was adjourned to September 9, proximo, at 7½ o'clock, P. M.

Five hundred and twelfth meeting.

September 9, 1862. — ADJOURNED STATED MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read a letter from the Librarian of the Royal Irish Academy, in reference to the disposition to be made of certain duplicate volumes of the Transactions of that Academy which have been found in the American Academy's library.

The President, as Chairman of the Committee on the Administration of the Rumford Fund, reported back the amendments to the Statutes and Standing Votes, which were again referred to them at the last meeting, with the following proposed additions: —

To the Statute, Chapter III., Section 3, it is proposed to add, "which are not chosen by ballot." The Statute, with this addition and a slight verbal change, will read:

The President, or in his absence the next officer as above enumerated, shall nominate members to serve on all the Committees of the Academy which are not chosen by ballot.

In Chapter IV., Section 1, strike out "upon nomination of the President," when the section will read:

At the Annual Meeting there shall be chosen the following Standing Committees, to serve for the year ensuing, viz.

Section 2 of the same chapter, which now reads, — "The Committee of Finance, to consist of the President, Treasurer, and one Fellow, who shall recommend to the Academy, from time to time, any measures that they may think ought to be adopted concerning the disposition and management of the funds and trusts of the Academy, including all questions of appropriations and expenditures," — to be amended so as to read:

The Committee of Finance, to consist of the President, Treasurer, and one Fellow chosen by ballot, who shall have charge of the investment and management of the funds and trusts of the Academy. The annual and any other appropriations from the general and publication funds shall be moved by this Committee.

Chapter VI., Section 4, which now stands, — “All moneys which there shall not be present occasion to expend, shall be invested by the Treasurer, on such securities as the Academy shall direct,” — to read :

All moneys which there shall not be present occasion to expend shall be invested by the Treasurer, under the direction of the Finance Committee, on such securities as the Academy shall direct.

Amendments were severally moved by Professor Peirce, Dr. B. A. Gould, and Professor Eliot. And the proposed Statutes and Standing Votes, with the proposed amendments, were re-committed to the same Committee, to be presented for final consideration at the next Statute Meeting.

Mr. T. H. Safford communicated a paper entitled, —
A Catalogue of Standard Stars : Polar and Clock Stars, for the Reduction of Observations in Right Ascension, with a Discussion of the Positions.

In computing the instrumental corrections for a transit-instrument, it is often useful to have a catalogue of stars near the pole, of some extent. The positions of these stars must be known with much accuracy beforehand for the current reductions ; and the further determination of their positions may be advantageously made one object of the observations.

Such is the process employed at the Observatory of Harvard College. The twenty-five stars within 10° of the pole, of which the discussion is given in this Memoir, are to be determined there ; the observations are partially made, in fact, and the positions here given serve for the daily reductions, to be afterwards corrected where necessary. These stars are so arranged as to give means of determining instrumental corrections at every hour in the night, and often of detecting changes which would otherwise be recognized with difficulty.

The right-ascensions of the clock-stars of the Nautical Almanac are also discussed in the Memoir, but with less detail. There may be systematic differences between the different available catalogues which require further investigation. The thirty-six stars whose places with those of α and δ Ursæ Minoris are given in Wolfer's *Tabulae Reductionum* are not rediscussed, but the right-ascensions there given are referred to 1855.0. These places depend upon a great many obser-

uations, and are probably the most accurate predicted star-positions in existence. They have been made the standard in the Memoir now laid before the Academy.

Professor Peirce made the following brief communication, —

On the Lunar Bolis.

In a memoir by the illustrious Plana "on the motion of the centre of gravity of a solid body, thrown towards the earth, between the centres of the moon and the earth, which are supposed fixed in space directly after the impulse," the attention of geometers is drawn to the hypothesis of the lunar origin of the bolis. This memoir deserves to be studied for its interesting mathematical developments. But the limitations of the problem, arising from the immobility of the moon and earth, remove the solution quite far from the case of nature. And yet it would seem that, in its unlimited form, the problem was beyond the powers of analysis. This is indeed the case, theoretically; but practically, the solution is greatly simplified by giving the moon its proper motion relatively to the earth.

The reason of this practical simplification is not difficult to perceive. The path of the bolis which actually comes from the moon to the earth must differ very little from a straight line; and it is only in the immediate vicinity of the moon that there can be any sensible motion perpendicular to the radius vector drawn to the earth. When the bolis leaves the sphere of the lunar action, then its velocity must be almost wholly in the direction of the radius vector drawn to the earth. A careful and critical analysis fully confirms this inference, which was indeed the basis of Dr. Gould's memoir upon the lunar origin of the aerolites, which was read at the Springfield Meeting of the American Association for the Advancement of Science, and establishes the conclusions of that original and able memoir.

Five hundred and thirteenth meeting.

October 14, 1862. — MONTHLY MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary presented the following botanical papers: —

1. *Characters of some New or Obscure Species of Plants, of Monopetalous Orders, in the Collection of the United States South Pacific Exploring Expedition under Captain Charles Wilkes, U. S. N. With various Notes and Remarks.* By ASA GRAY. (Continued from Vol. V. p. 352, November, 1861.)*

Cyrtandra Polynesienses.

SINCE the publication of the diagnoses of the *Cyrtandra* of the Sandwich Islands, specimens collected in our Expedition at the Society and Samoan or Navigators' Islands, accidentally mislaid, have come to light. *C. biflora*, the original of the genus, is the only one recorded from the Society Islands. But we have now tolerable materials of two other Tahitan species, as well as four or five from the Samoan or Navigators' Islands.

CYRTANDRA BIFLORA (Forst.): arborea, pube furfuracea crocea nascentium partium mox delapsa glaberrima; foliis (3-5-pollicaribus) ovato- seu lanceolato-oblongis utrinque subacutis lævibus subtus palli-

* *Cyathodes Douglasii*, of the preceding paper, p. 325, proves to be *C. imbricata*, Stschelglew, in Bull. Soc. Mosc. 32, p. 10, a memoir published in the year 1859, which I had overlooked.

Nama. The following is supplementary to the revision of this genus published in the preceding paper, p. 337:—

Specimens of two new species of *Nama*, collected somewhere in the interior of California, probably in the southern part of the country, by Mr. Lobb, have been communicated to me from the Hookerian herbarium. They do not fall well into place under any of the divisions in my revision; but one of them might stand next to *N. origanifolia*, although it has the inflorescence of *N. sericea*; the other should be placed between *N. hispida* and *N. sericea*, having the white villosity of the latter and the slender sepals of the former. The distinctive characters are annexed.

NAMA LOEBII (sp. nov.): albo-pilosa; caule basi suffruticuloso; foliis anguste spathulatis basi longe attenuatis vix petiolatis subtus pilis arachnoideis albo-villosis; floribus subsessilibus congestis; sepalis angustissime linearibus sursum attenuatis corollæ tubum (limbo paullo longius) subæquantibus; ovario stylisque hirsutis. Corolla 5 lin. longa. — California, Lobb, No. 108.

NAMA SYSTYLA (sp. nov.): viscoso-hirsutula; caule debili; foliis ovatis petiolatis; pedunculis gracilibus cymoso-plurifloris; sepalis angustissime linearibus superne haud dilatatis hispidis corolla triplo brevioribus; stylis longe ultra medium connatis inferne cum ovario hispidis. Corolla semipollicaris, angusta. — California, Lobb, No. 164. The connate styles, united for more than two thirds their length, are peculiar to this species.

dis crenato-sub serratis vel subintegerrimis; pedunculis petiolum paullo excedentibus "involucrum albidum 2-3-phyllum caducum pedicellosque 2-3, unifloros gerentibus"; calycis quinquefidi lobis lato-lanceolatis sensim acuminatis; corolla bipollicari; fructu oblongo. Folia adulta in sicco chartacea, venis paginæ inferioris albidæ perspicuis at vix prominulis.—Tahiti. Also, Tutuila, of the Samoan Islands, unless there has been transposition of specimens. Our specimens are very incomplete, wanting the corolla, calyx, &c. The above character is completed partly from Forster's figures, and his detailed description printed in Guillemain's *Zephyritis Taitensis*, and partly from notes upon his specimen in the herbarium of the British Museum. Hooker and Arnott, in *Bot. Beech. Voy.*, having introduced the phrase "calyce pubescenti-tomentoso" into the character, must have had one of the following Tahitan species in view, and so probably had De Candolle. The nearest relative of *C. biflora* is the following, from the Samoan Islands.

CYRTANDRA PULCHELLA (Rich in herb. Expl. Exped., sp. nov.): "fruticosa, tripedalis," glaberrima; foliis oblongo-lanceolatis (5-9-pollicaribus) subfalcatis basi subcuneata inæquilatera versus apicem repando-crenatis supra nitidis subtus pallidis; pedunculis folio paullo brevioribus 7-9-floris; "bracteis latis" caducis; calycis coriacei breviter inæqualiter quinquefidi lobis ovatis obtusis; corolla bipollicari; ovario elongato.—Tutuila, one of the Samoan Islands, on the mountain ridge. Peduncles 4 or 5 inches long up to the bifurcation, stout, inclined to become fistulous. Anthers, as in all the following species which have an elongated and dry berry, with the cells perfectly parallel, and the stigma is 2-lobed; so that they are truly of this genus.

CYRTANDRA INDUTA (sp. nov.): arborescens, foliis inæqualibus (altero 5-8-, altero 8-14-pollicari) ovatis seu ovali-oblongis acuminatis dentatis basi inæquilatera sæpius acutis pilis pluriseptatis supra hirsutis subtus cum petiolis pedunculis ramisque junioribus molliter villosis; pedunculis petiolo æquilongis plurifloris; calyce infundibuliformi pubescente, lobis lanceolatis acuminatis tubo 2-3-plo brevioribus; corolla bipollicari; fructu immaturo elongato-oblongo basi attenuato quasi stipitato.—Tahiti, in the mountains, at the elevation of 2000 to 3000 feet, collected by Professor Dana. I have a less downy specimen, communicated by M. Pancher, said to be very common in moist valleys of Tahiti, the pubescence of the lower surface of the leaves ferrugineous. This has been confounded with *C. biflora*, but it is wholly

distinct. Calyx nearly an inch and a half long when full grown, acute at the base. The forming fruit an inch and a half long, including the attenuate base.

CYRTANDRA TAITENSIS (Rich in herb. Expl. Exped., sp. nov.): fruticosa, "8-10-pedalis," puberula vel glabella, partibus novellis pube minuta sericea subferrugineis; foliis fere æqualibus ovatis seu ovato-oblongis acutis vel acuminatis subserratis (6-12-pollicaribus), adultis supra hirtulo-scabridis subtus ad costas prominulas venulasque puberulis; pedunculis petiolo 3-4-plo longioribus plurifloris; calyce campanulato brevi ad medium quinquefido, lobis ovato-acuminatis; corolla sesquipollicari, tubo gracili; fructu immaturo elongato-oblongo haud basi attenuato. — Tahiti, in the forest. One specimen is ticketed "Samoa," but as one specimen of the following species is ticketed "Tahiti," a transposition of the loose tickets may be strongly suspected. Petioles slender, 12 to 18 lines long. Peduncles often thickish, and inclined to be fistulous, 3 to 6 inches long. Cyme apparently loose and rather many-flowered, three or four times dichotomous, with a flower in each fork. Corolla white; the tube narrower and the limb smaller than in the foregoing species.

CYRTANDRA SAMŒNSIS (sp. nov.): frutescens, novellis partibus minutim ferrugineo-vel fulvo-pubescentibus; foliis ovatis ovalibusque (6-12-pollicaribus) æqualibus utrinque sæpius acutis vel subacuminatis subdentatis vel fere integerrimis, adultis supra glabratibus subtus albidis ad costas prominulas venulasque pubescentibus, petiolo (sesqui-quadripollicari) cymis plurifloris breve-pedunculatis bis terve longioribus; calyce tenuiter pubescente a basi 5-(-6-) partito, segmentis lato-lanceolatis corolla semipollicari paullo brevioribus; fructu breviter ovoideo. — Tutuila, Savaii, and Manua, Samoan Islands, along the coast. A specimen is ticketed "Tahiti," probably through a transposition. This should be compared with *C. latifolia*, Benth., a Feejean species not yet met with in later collections, which, however, has peduncles 2 or 3 inches, and the petiole only an inch long. In the present species, the peduncle is half an inch, or at most an inch long, the corymbose or umbel-like cyme about the same length. Forster's *C. cymosa*, from Tanna, as described by Vahl, also has peduncles surpassing the petiole.

CYRTANDRA RICHII (sp. nov.): glabra; caule fruticoso crasso (10-15-pedali); foliis amplis (1-2-pedalibus) membranaceis lanceolato-oblongis basi attenuatis subintegerrimis utrinque viridibus; cymis sub-

sessilibus fasciculiformibus petiolo brevioribus; "corolla viridula suburceolata parvula"; fructu immaturo ovoideo. — Savaii, one of the Samoan Islands, in the deep, interior forest. Petioles 3 or 4 inches long, stout. Calyx and also the corolla not seen by me.

CYRTANDRA LABIOSA (sp. nov.): glabra, præcedenti affinis, sed foliis lato-lanceolatis multo minoribus (6–7-pollicaribus); "floribus majoribus; corolla alba eximie bilabiata." — Savaii, Samoan Islands. Loose corollas with the very imperfect specimens appear to be short and broad, deeply bilabiate, the lips twice or thrice the length of the tube, the upper one arching, the lower spreading.

CYRTANDRA POGONANTHA (sp. nov.): frutescens; foliis amplis (pedalibus) utrinque acutis vel basi attenuatis subintegerrimis glabratibus viridibus membranaceis, nascentibus ferrugineo-pubescentibus; cymis petiolo brevioribus involucreis brevi-pedunculatis hirsutis; alabastris (calycis) rostrato-acuminatis; corolla tubulosa breviter bilabiata (lobis conformibus ovatis subacutis) extus pilis longis pluriseptatis insigniter barbata. — Savaii, Samoan Islands, in the deep, interior forest. The calyx in anthesis apparently splits down one side to near the middle. Corolla an inch long; the bearded whitish hairs which cover the outer surface, especially of the limb, are remarkable. In structure they resemble those of the petioles and branches of the two following species. Stamens 2, as of the genus; anthers exerted from the throat. *Fruit not seen.*

The following are the Feejean species of our collection.

CYRTANDRA MILNEI (Seem. in Bonplandia, 9, p. 257, absq. char.): caule crasso; ramis petiolis costaque foliorum rufo-villosissimis, pilis longis multiseptatis superne attenuatis; foliis (5–8-pollicaribus) ovalibus utrinque acutis vel acuminatis serratis pilosis; pedunculis brevissimis plurifloris; bracteis amplis; calyce pedicello longiori tubuloso fere æqualiter 5-dentato persistente fructus ovatum includente. — Feejee Islands. This remarkable species we have in fruit only; the corolla and stamens therefore unknown to me. The very shaggy petioles 3 or 4 inches long; the blade of the leaf conspicuously veiny. Fructiferous calyx 7 to 10 lines long, cylindraceous or tubular-cyathiform, glabrate, longer than the included even full-grown fruit.

CYRTANDRA DOLICHOCARPA (sp. nov.): frutescens; ramis gracilibus, junioribus cum petiolis pedunculisque (unifloris?) pilis longis rufescentibus multiseptatis (modo *C. Milnei*) barbatis; foliis subæqualibus lanceolato-oblongis acuminatis denticulatis supra hispidulis subtus

breviter fulvo-pubescentibus; calyce longe tubuloso fructu cylindrico siliquæformi ($1\frac{1}{2}$ –2-pollicari) acuto $\frac{1}{3}$ brevior sèro deciduo. — Sandalwood or Mbua Bay, Vanua-levu, Feejee Islands. A solitary specimen, in fruit only. Evidently allied to *C. Milnei*, by the pubescence, tubular calyx, &c. The latter is made out from vestiges which remain upon one side of one of the fruits, showing that it attains fully an inch in length. Yet it is exceeded by the singularly elongated fruit, which, except in form, resembles that of other species of *Cyrtandra*, i. e. is corticate, probably fleshy when fresh, but juiceless, and indehiscent. The stamens must determine whether its relationship is with *Fieldia* or *Whitia* (the latter probably no good genus); but other Polynesian species exhibit a similar, only less elongated fruit.

CYRTANDRA INVOLUCRATA, Seem. l. c. A very imperfect specimen, from Ovolau, appears to belong to this species (the involucre fallen); but my specimen from Dr. Seemann wants the flowers, that of the Expedition the fruit, and both the corolla, — so that I cannot properly identify them nor furnish a specific character. In ours, the calyx is rostrately acuminate in the bud, the lobes subulate from a broad base and about the length of the ovoid-campanulate tube.

CYRTANDRA ANTHROPOPHAGORUM (Seem. l. c.): frutescens, minutim fusco-pubescent; foliis oblongis acuminatis subserratis (3–5-poll.); pedunculis petiolo brevioribus paucifloris, pedicellis flore longioribus; calyce ad medium 5-fido, lobis subulato-lanceolatis corolla (semipollicari) dimidio brevioribus; fructu ovato-oblongo. — Ovolau. The flower is described from scanty materials in the collection of the Expedition, the young fruit from that of Dr. Seemann.

CYRTANDRA PRITCHARDI, Seem. l. c. Ovolau. Dr. Seemann's materials are probably much better than ours.

The Feejee Islands are apparently as rich as the Sandwich Islands in species of *Cyrtandra*. Besides those above mentioned, Dr. Seemann has the following undescribed ones, which are not in the Exploring Expedition's collection: *C. acutangula*, with square branches; *C. Vitiensis*, with a tubular calyx; *C. coleoides*, and *C. ciliata*. None of these wholly accords with one collected by Prof. Harvey, nor with the characters of Bentham's *C. calycina* and *C. latifolia*. The former must, by its calyx, be of the same group with *C. Vitiensis*, *C. Milnei*, &c.

Gentianaceæ.

ERYTHRÆA SABÆOIDES. *Schenkia sabæoides*, Griseb. in Bonplandia, 1, p. 226. This plant was not met with by the naturalists of

Wilkes's Expedition. But having examined a specimen of Seemann's no. 2272, and of Remy's no. 375, from Oahu, I cannot regard the plant as other than a close congener of the plant which it most resembles, viz. *Erythraea spicata*. The leaves are broader and rounder, being broadly oval, the tube of the corolla proportionally shorter and its lobes broader; the sepals are less narrow and more carinate, or, if you please, winged on the back. But this varies somewhat, even in the sepals of the same flower, and at most is only a matter of degree, the sepals being carinate, at the base sharply so, in *E. spicata*. So other American species effect a transition in this respect to *Gyrandra*, Griseb. (*Erythraea chironioides*, Torr.). Grisebach describes the stigma of his *Schenkia* as "capitulatum," or "crassiusculum"; but there must be some mistake or confusion here. For in Seemann's own specimens, which I have examined, as also in those of Remy, the stigma is very large and just as in *E. spicata*, that is, appearing as this organ is characterized by Grisebach in the section *Spicaria*, but upon maceration separating completely into two nearly orbicular flat divisions.

In *Erythraea* generally I cannot verify the character "corolla supra capsulam contorto-marcescens."

LIMNANTHEMUM KLEINIANUM, Griseb. var.? Imperfect specimens of a *Limnanthemum* from the Feejee Islands, said to be "common in Taro ponds, and probably introduced," (and similar ones were collected there by Dr. Harvey,) accord, except in their smaller leaves, with Dr. Seemann's 323, referred by him to *L. Kleinianum*. But they differ from my only Indian specimen of the latter (from Maisor or the Carnatic, coll. Thomson and Hooker) in not having three ribs prominent underneath, in their smaller flowers (the corolla in all too poor for investigation), and in their flat and acute-edged, perfectly smooth seeds. Those of the Indian specimen referred to are not badly represented in Hook. Bot. Misc. 3, suppl. t. 30, in the figures which Grisebach excludes from the species, being turgid, obtuse at the margin, and their face minutely muricate by fine spiculæ, which, however, may be readily rubbed off.

Solanaceæ.

SOLANUM NELSONI (Dunal in DC. Prodr. 13, p. 123?): inerme, pube stellata fulvo- seu flavido-tomentosum; caulibus fruticosis procumbentibus; foliis cordatis vel rotundo-subcordatis integerrimis utrinque molliter tomentosis sæpius cum axillari parvo; racemo paucifloro

pedunculato demum laterali; floribus extus tomentosis; calycis lobis ovatis obtusis corolla 5-fida plicata triplo breviori; antheris apice attenuatis incurvis filamento (in sicco bullato-rugoso) subduplo longioribus. *Solanum argenteum*, Hook. and Arn. Bot. Beech. ? *S. rotundifolium*, Nutt. in herb. Hook. — Sandwich Islands, on the sands of the low isthmus of Maui. Collected by Nuttall on Kauai, and on Oahu by Remy, no. 442. Without having seen Nelson's specimen in the Banksian herbarium, upon which Dunal, in the year 1819, drew up his character of *S. Nelsoni*, we may presume, notwithstanding some discrepancies, that it is the species here described from ampler materials. But it does not belong to his division *Pachystemonum*. The anthers, although rather short, are strongly attenuate at the summit, and the cells open by a minute and strictly apical pore. Branches perhaps sarmentose. Leaves an inch or two in length and breadth.

SOLANUM SANDWICENSE (Hook. & Arn.): fruticosum, inerme; foliis sublonge petiolatis ovatis (basi obtusa vel rotundata) integerrimis undulatis vel angulato-sinuatis supra pube stellata minuta parce delapsa glabratis subtus ramis floribusque cano- seu ochraceo-tomentosis; cymis pedunculatis plurifloris demum lateralibus, pedicellis gracilibus; calycis lobis subulatis corolla fere 5-partita (segmentis æstivatione valde induplicatis, evolutis ovalibus obtusis) 3-4-plo brevioribus; antheris oblongis arcuatis apice subattenuatis, poris apicalibus. Ludit indumento tenuiore minus incano, et in var. ? β . crassiore furfuraceo. *S. Sandwichense* & *S. Woahense*, Dunal in DC. — Oahu, Sandwich Islands.

Var. ? β . **KAVAIENSE**: foliis ovato-oblongis magis acuminatis, tomento furfuraceo; calycis lobis angustissimis. — Kauai, on the leeward verge of its tabular summit.

SOLANUM INCOMPLETUM (Dunal, l. c.): frutescens, subtomentosum, aculeis igneis validis (aut perpaucis aut numerosis, præcipue foliaribus rarissime caulinis) armatum; foliis longe petiolatis ovalibus oblongisve sinuatis vel subpinnatifidis (lobis brevibus obtusissimis) supra stellatopuberulis subtus cum inflorescentia fulvo- seu ochraceo-tomentosis; pedunculis lateralibus brevissimis plurifloris; calycis lobis brevibus obtusis; corolla profunde 5-fida (alba?), segmentis oblongis arcuatis sursum vix attenuatis, poris apicalibus majusculis; baccis globosis parvis. Hawaii, Sandwich Islands, Nelson (without flowers or fruit), Remy (no. 451, a very aculeate state, in blossom), and fruiting specimens in the collection of the Expedition. Apparently only a foot or so in height, and barely woody at the base. Leaves $1\frac{1}{2}$ to 2 inches long,

and the petiole 6 to 14 lines in length. Berries half an inch or less in diameter.

SOLANUM VIRIDE, Solander, from various South Sea Islands, apparently includes *S. anthropophagorum*, Seemann, from the Feejees.

SOLANUM INAMENUM, Benth., of the Feejee Islands, does not present tortuous branches; the leaves are seldom oblique; and cymes are often bifid.

SOLANUM AMICORUM, Benth., from Tongatabu. In the same group of islands, Dr. Harvey collected fine specimens; the globular fruit resembling that of the preceding species.

SOLANUM REPANDUM, Forst. The "Feejee Tomato" appears to be a variety of this species, altered by cultivation, the ovary nearly glabrous, the fruit completely so, and "as large as an apple."*

LYCIUM SANDWICENSE (sp. nov.): glabrum; ramis rigidis; foliis subcarnosis aveniis spathulatis obtusissimis basi attenuatis vix petiolatis plerisque fasciculatis; pedicellis solitariis folio brevioribus; floribus tetrameris; calycis breviter quadrifidi lobis late triangularibus corollæ tubum adæquantibus; corollæ lobis tubo suo longioribus patentissimis; filamentis basi glaberrimis; bacca globosa. — Sandwich Islands, on Diamond Hill, Oahu, near Honolulu. Dr. Pickering, whose judgment in this regard is critical, records it as undoubtedly indigenous; and it does not accord with any one of Mr. Miers's sixty-nine described

* The following is a North American species, which occurs in several collections:—

SOLANUM TORREYI (sp. nov.): perenne, aculeis rectis breviusculis parce armatum vel subinermis, griseo-pubescentibus pube stellata scabrida; foliis sinuato-pinnatifidis basi truncata vel subcordata, lobis 3–7, terminali undulato vel repando, costa pl. m. aculeato; cyma terminali demum laterali bifida; pedicellis defloratis recurvis; calycis tubo brevi-campanulato, lobis e basi lata caudato-acuminatis; corolla ampla ($1\frac{1}{2}$ –2 pollices lata) semiquinquefida violacea; antheris conformibus flavis elongatis apice attenuatis stylo apice incurvo brevioribus; bacca globosa (pollicem lata viridi demum lutea) calyce tum denique 5-partito subtensa. — *Solanum mammosum*? Engelm. & Gray, Pl. Lindh. 1, p. 46, no. 281, non Linn. *S. platyphyllum*? Torr. in Ann. Lyc. N. Y. 2, p. 227, non Dunal. *S.* —, Torr. & Gray in Pope, Rep. Pacif. R. R. Surv. 2, p. (172) 16. This species is not rare from the Upper Arkansas to Lower Texas. At New Braunfels, according to Lindheimer, it is common in clayey soil, wherever the original vegetation has been destroyed by men or cattle. It has long survived in the Cambridge Botanic Garden, where it spreads by running subterranean shoots, and the large flowers are rather showy. Having for many years vainly endeavored to identify the plant with some described species, I at length venture to publish it as new.

species. It occurs in no other collection that I know of, yet it was found in a district which has often been botanized over. The peculiarities of the species are its fleshy leaves, and tetramerous flowers, with the corolla so deeply cleft that it falls into Miers's section *Macrocope*. Otherwise it approaches *L. vulgare*, but it is without hairiness at the base of the filaments. Berry "saline to the taste, but edible."

The North American species, represented in Dr. Torrey's herbarium and my own, on examination, give the subjoined results.*

* *LYCIA AMERICÆ BOREALIS*.

§ 1. Flores majores: corolla infundibuliformi-tubulosa, ultra-semipollicaris (9-10 lin. longa, viridula): calyx laxè campanulatus, usque vel ultra medium 5-fidus, lobis subfoliaceis patentibus; antheræ mucrone deciduo superatæ. Glabra.

1. *L. pallidum*, Miers, Monogr. in Contrib. 2, p. 108, t. 67, C.; Torr. in Bot. Mex. Bound. p. 154. — New Mexico and adjacent parts of Arizona, Fendler (670, 668^b), Bigelow, Thurber, Fremont, Newberry.

Forma α : filamentis et corolla intus glaberrimis. Spec. Fendler, Newberry, &c.

Forma β : filamentis tuboque corollæ intus pilosulis (spec. Thurber) vel hirsutis (spec. Fremont e Rio Virgen).

This difference in respect to the smoothness or hairiness of the filaments and base of the corolla inside, in what is evidently the same species, throws doubt upon the value of that character in the rest of the genus. No other evidence of dimorphism is observable. Mr. Miers described the species from the smooth form; yet he noticed (what I have not detected in Fendler's specimens) some hairs below the insertion of the filaments. The lobes of the calyx ($1\frac{1}{2}$ to 2 lines long) are seldom "lineari-acutis"; they vary from lanceolate to ovate, and are often very obtuse.

§ 2. Flores mediocres sed breves: corolla semipollicaris vel brevior, limbi rotato-expansi lobis 4-5 tubo mox longioribus. Glabra, foliis carnosius.

2. *L. carolinianum*, Walt., Michx. — Coast of South Carolina to the Mexican boundary (Texas, Drummond, Coll. 2, 244). I have it not under the numbers of Berlandier cited by Miers. Filaments very densely tomentose-bearded for a short distance just above the insertion.

§ 3. Flores minores: corolla $\frac{1}{8}$ - $\frac{1}{2}$ -pollicaris, lobis tubo (sæpissime multum) brevioribus.

* Calyx profunde 5-fidus, lobis tubo suo longioribus corollæ angustæ apice breviter 5-lobæ dimidium fere attingentibus: pedicelli nulli vel brevissimi. Puberulæ, spinosæ.

3. *L. macrodon* (sp. nov.): ramis junioribus pubescentibus; foliis glabratissimis spatulato-oblancoelatis enerviis fasciculatis (2-4 lin. longis); pedicellis brevissimis (ad summum sesquilinearibus); calycis minutum viscosi lobis anguste linearibus tubo breviter campanulato (sesquilineali) duplo longioribus; filamentis versus basin hirsutulis. — California, in the interior? Coll. Fremont in Expedition to California, 1849, Herb. Torr. Corolla half an inch long, narrow. Anthers oval-oblong, slightly if at all exserted.

The three following *Solanaceæ* of the Sandwich Islands, which I cannot refer to any known genus, are here characterized from materials

4. *L. PUBERULUM* (sp. nov.) : foliis obovatis vel oblongo-spathulatis subtus uninnerviis fasciculatis (4–8 lin. longis) cum ramulis gracilibus calycibusque minutim pruinoso-pubescentibus ; floribus sessilibus ; calycis lobis angusto-oblongis obtusis tubo subhemisphærico longioribus ; filamentis glabris. — Western borders of Texas, near El Paso, C. Wright, no. 1609. “A much branched shrub, 2 to 4 feet high ; tube of the corolla white, the margin yellowish-green.” Spines numerous and slender. Lobes of the calyx a line and a half long, very blunt. Corolla $4\frac{1}{2}$ or 5 lines long, the short lobes recurved, ovate ; the tube within pubescent below the insertion of the glabrous filaments : anthers cordate-globular.

* * Calyx insigniter 4–5-dentatus, dentibus lanceolatis tubo suo parum brevioribus : pedicelli calyce breviores vel æquilongi. Glabræ vel fere glabræ, spinulentis.

5. *L. BREVIPES*, Benth. Bot. Voy. Sulph. p. 40 ; Miers, l. c. p. 117, t. 69 C. — Lower California, Hinds and Barclay, Xantus, no. 89 ? without flowers or fruit. Our herbaria afford no materials for this species. We have nothing from that region, or indeed from elsewhere, with the calyx scarcely a line long, and yet longer than the pedicel, its teeth lanceolate and acute, and the corolla five lines long, or in the imperfect flower figured by Miers three lines long. A fragment in herb. Torr., from California, Rev. Mr. Fitch, somewhat accords with the character, except in the calyx-teeth, which are very short and broad.

6. *L. RICHII* (sp. nov.) : foliis spathulatis (3–5 lin. longis), novellis tenuissime puberulis vel fere glabris ; floribus tetrameris ; calyce campanulato pedicello (1–2 lin.) longiori vel æquilongo, dentibus lato-lanceolatis acutiusculis tubum subæquantibus ; corollæ (4 lin. longæ) tubo calyce et lobis ipsis duplo longiori intus glabro ; filamentis basi villosis. — La Paz, South California, Major Rich. California, Rev. A. Fitch (Herb. Torr.). The latter specimen has the young leaves minutely puberulent, the former scarcely if at all so. Teeth of the calyx inclined to become recurved-spreading. Lobes of the corolla 4, oval, not ciliolate, not exceeded by the filaments. Anthers oblong.

* * * Calyx breviter vel brevissime 4–5-dentatus, sæpe hinc vel bi-trilabiatis fissus, dentibus segmentisve latis.

+ Subpuberulum : filamenta nuda vel basi vix pilosa (corollam haud superantia).

7. *L. FREMONTI* (sp. nov.) : foliis spathulatis ($\frac{1}{2}$ – $\frac{3}{4}$ -pollicaribus) cum pedicellis calycibusque tenuiter puberulis ; calyce cylindræo quam pedicellus gracilis breviori, tubo dentibus quadruplo longiori ; corolla tubulosa, tubo lobis 5 quadruplo longioribus ; filamentis prorsus glabris. (*L.* near *fragosum*, Miers, in herb. Torr. ; Torr. in Pacif. R. R. Exped. 4, p. (71) 127.) — Interior of California or country east of it, Fremont, Coll. Exped. 1849. Williams's Fork of the Colorado, between California and New Mexico, Dr. Bigelow, a form with narrower leaves and smaller, more slender flowers, — i. e. calyx about 2 lines and corolla $4\frac{1}{2}$ lines in length ; the tube of the latter pubescent inside in lines below the stamens ; while in the type of the species, the calyx is 3 lines, pedicels 4–7 lines, and corolla 6 lines in length ;

which are both scanty and imperfect. Attention being thus directed to them, perhaps these materials may be supplemented from some other

the latter, I believe, like the filaments, wholly glabrous; the lobes in both not ciliate. Anthers oval.

Var. β ? BIGELOWII: pedicellis abbreviatis calyce subturbinato (2 lin. longo) magis dentato vix æquilongis; filamentis corollaque intus basi parce hirsutulis. — Cañons of Williams's Fork of the Colorado, Dr. Bigelow. Perhaps a distinct species; but, as it was collected with one of the above specimens, and the materials of all three are scanty, I cannot venture to consider it so.

+ + Glabrum: filamenta basi villosa: pulvilli fasciculorum foliorum sæpius lanulosi. — Species a longifloris ad brevifloras ordinatæ.

8. *L. TORREYI* (*L. barbinode*, Torr. in Pacif. R. R. Exped. 5, p. 363, & Bot. Mex. Bound. p. 154, non Miers, Monogr.): foliis lanceolato-spathulatis crassiusculis (semi-subsesquipollicaribus); pedicellis fasciculatis (2-5 lin. longis); floribus pentameris; corolla tubuloso-infundibuliformi (5-6 lin. longa) calyce subæqualiter 5-dentato quadruplo longiori, lobis suis tomentoso-ciliatis. — Texas, on the Rio Grande, to Fort Yuma, interior of California, along the Mexican boundary, collected by Fremont, Major Thomas, Thurber, Bigelow, Schott, and Wright (1609, in herb. Gray, probably an error, as *L. puberulum* bears this number also: 1604 and 1608 in herb. Torr., but I have no *Lycium* under the former number). Calyx campanulate; the teeth about a third or more of the length of the tube, often tomentulose-ciliate. Lobes of the "blue or purple" corolla always bordered by a fine white tomentum, the throat or portion above the insertion of the stamens elongated and narrow, very gradually enlarging upwards, about one third of the length of the tube, nearly equalling the stamens. The flowers abundantly distinguish this species from the next, — for which, however, Mr. Miers mistook an insufficient specimen in herb. Torrey. We now have it in great abundance.

9. *L. BARBINODUM* (Miers, l. c. p. 115, t. 68, E.): foliis lineari-spathulatis (semi-subpollicaribus); pedicellis (sesquilineam longis) calycem æquantibus; floribus pentameris; corolla e tubo angusto superne campanulata (3 lin. longa) calyce sæpius fisso duplo-subtriplo longiori, lobis brevibus parce pilosulo-ciliatis. — Mexico, on the table land of Durango, Seemann, 2090. Unless a specimen of Thurber's collection from Sonora, in fruit only, belongs here, this species is known solely from Seemann's specimens: from one of these the above character is derived. It will be found to accord well with the description published by Miers, but not, as respects the shape of the corolla, with his figure. We ought not to rely too much upon this (as the following species shows); but the phrase "corollæ tubo imo coarctato, hinc repente campanulato . . . laciniis . . . margine subciliatis," accords perfectly with an authentic specimen in my herbarium. The corolla, moreover, is only about half the length of that of the preceding species.

10. *L. BERLANDIERI* (Dunal in DC. *L. stolidum* & *L. senticosum*, Miers, l. c.): foliis lineari-spathulatis seu linearibus basi attenuatis (4-7 lin. longis); floribus sæpissime tetrameris pedicello ($1\frac{1}{2}$ -3 lin.) subduplo vel parum longioribus; corolla (3-3 $\frac{1}{2}$ lin. longa) infundibuliformi fauce ampliata calyce brevi 3-4-plo longiori

collection. From the shape of the unripe seeds it is probable that the embryo is curved.

NOTHOCESTRUM, *Nov. Gen.*

Calyx campanulatus 4-dentatus vel subbifidus, immutatus. Corolla breviter hypocraterimorpha, limbo 4-partito, lobis ovatis æstivatione valvato-induplicatis. Antheræ 4, infra faucem insertæ, sessiles, lineares, inappendiculatæ, loculis introrsum longitudinaliter dehiscentibus. Discus hypogynus nullus? Ovarium globosum, estipitatum, biloculare, loculis pluriovulatis: stylus breviusculus: stigma bilobum: ovula subcampylotropa. Bacca calyce suffulta. Semina subreniformia, majuscula. — Arbores vel frutices, *Cestri* seu *Lycii* facie, Sandwicenses, foliis alternis integerrimis, pedunculis unifloris seu pedicellis in axillis foliorum solitariis vel fasciculatis.

NOTHOCESTRUM LATIFOLIUM (sp. nov.): foliis subpuberulis late ovalibus seu ovatis obtasis; corolla extus subsericea, tubo calyce breviter campanulato duplo longiore; bacca globosa. — Oahu, on the ridge of the Kaala Mountains. "Shrub about 12 feet high." Leaves membranaceous, about 2 inches long. Pedicels fascicled. Calyx 3 lines long. Corolla white? its tube half an inch long; the lobes not half the length of the tube, their margins strongly induplicate and the sinuses plaited. Anthers almost two lines long.

NOTHOCESTRUM LONGIFOLIUM (sp. nov.): glabrum; foliis oblongo-lanceolatis oblongisve basi attenuatis; pedunculis solitariis; calyce obtuse 2-4-dentato longiuscule campanulato; bacca (immatura) elongato-oblonga. — Oahu, on the mountains behind Honolulu, at

nunc breviter quadriloba nunc altius 4-fida. — Texas and the adjacent parts of Mexico along the Rio Grande, from its mouth to Monterey and to the borders of Arizona, Berlandier (1411, 1426, 1788, 3022), Gregg (199), Wright (540, 542, 1610), Bigelow, Thurber, Schott. Corolla "white," fully 3 lines long; the lobes varying from one fourth to one third the length of the undivided portion, or in the older flowers sometimes reaching almost to the middle. Stamens and style usually exerted. Calyx with 4 broad, blunt, equal or unequal teeth, sometimes splitting deeply on one or two sides. Berries red.

11. *L. PARVIFLORUM* (sp. nov.): foliis lineari-spathulatis (2-5 lin. longis); floribus tetrameris brevi-pedicellatis; corolla (2 lin. longa) calyce 2-3-plo longiori, fauce ampliata, lobis tubo dimidio brevioribus. — Arizona (Sonora), Thurber; also Dr. Parry, without indication of particular locality. Perhaps this may pass into the foregoing; but the flowers are smaller, and the corolla proportionally much shorter. Calyx either equally 4-toothed or 2-3-cleft. Stamens inserted very low down on the corolla. Pedicels a line or a line and a half in length.

the elevation of 1,500 feet. Leaves 4 to 7 inches long, thin. Pedicels 6 to 9 lines long. Corolla not seen. Testa of the immature seeds reticulated.

NOTHOCESTRUM BREVIFLORUM (sp. nov.): arboreum, fere glabrum; foliis anguste oblongis ellipticis; corollæ tubo calycem 2-4-lobum vix superante. — Hawaii, "between the Great Crater and the upper base of Mouna Roa. A tree 20 feet high, with the trunk 5 inches in diameter and the wood greenish: habit of *Solandra viridis*; the flowers greenish, but small." Pickering. Leaves $2\frac{1}{2}$ to 4 inches long, rather coriaceous. Calyx $4\frac{1}{2}$ lines long, 4-nerved. Corolla, &c. nearly as in *N. latifolium*, but shorter. Fruit not seen.

Scrophulariaceæ.

CALCEOLARIA PETIOLARIS, Cav., is the name of this species, as written by Cavanilles; but every succeeding author, except Sprengel, has changed it to *C. petiolaris*, which makes a decided misnomer, and has caused already the introduction of two useless synonymes.

CALCEOLARIA BARTSIÆFOLIA, Wedd. Chlor. And. Andes of Peru, above Baños. This we had thus named in our collection long before the appearance of Weddell's work, so obviously appropriate is the specific name.

CAPRARIA CALYCINA (sp. nov.): glabra, humilis; foliis lanceolatis seu linearibus paucidentatis, dentibus grossis divaricatis plerumque versus basim; floribus in axillis solitariis; calycis laciniis foliaceis pedunculo æquilongis seu longioribus corollam adæquantibus capsulam superantibus; staminibus 4; stigmate emarginato. — Hunter's River, New South Wales. The only ground of suspicion as to the correctness of the habitat is, that all the species before known are American. This is related to *C. biflora*: it differs in its solitary and short-peduncled flowers, and its calyx of twice the size, with lanceolate, foliaceous, accrescent divisions, in flower 4 lines, in fruit half an inch long, sometimes slightly denticulate.

Verbenaceæ.

LIPPIA SERIPHIODES (sp. nov.): fruticosa, intricato-ramosissima, puberulo-scabrida; ramis rigidis; foliis minimis ($1-2\frac{1}{2}$ -lin. longis) fasciculatis lineari-spathulatis cuneatisve sæpius trilobis margine revolutis; capitulis globosis demum elongandis ex axillis breviter pedunculatis solitariis vel subracemosis; bracteis ovatis concaviusculis calyce oblongo

breviter bifido brevioribus; antheris superioribus sæpe (non semper) e connectivo glanduloso-appendiculatis. — Rio Negro, North Patagonia, on the upland plain. This, I believe, occurs in the Hookerian herbarium, in the collections of Tweedie and of Gillies, and was by the latter called *Verbena rubiginosa*, a name never published, and now preoccupied in *Lippia*.

CLERODENDRON INERME, R. Br., var. β . OCEANICUM: foliis majoribus ($2\frac{1}{2}$ –5-pollicaribus) magis acuminatis; calyce truncato denticulis 5 minutis; cymis nunc 5–7-floris. — Samoan, Tonga, and Feejee Islands. This must be Forster's *Volkameria inermis*, and perhaps Sprengel's *Clerodendron Commersonii*. I have seen no intermediate forms (though they probably occur) between this and the true *C. inerme* of India, &c., which has smaller and blunter leaves, and, as described by Schauer, a distinctly 5-toothed calyx, "dentibus lato-triangularibus acutis."

CLERODENDRON, sect. TETRATHYRANTHUS. Limbus calycis et corollæ quadrilobus, fere regularis.

CLERODENDRON (TETRATHYRANTHUS) OVALIFOLIUM (sp. nov.): foliis ovalibus obtuse acuminulatis integerrimis basi subangustatis (cum petiolo ramisque teretibus) glabris; cymis plurifloris corymboso-paniculatis canescenti-puberulis; corolla hypocraterimorpha, tubo (ultrapollicari) calycem obtuse 4-lobum pluries excedentibus, lobis 4 rotundatis inter se æqualibus stamina adæquantibus. — Feejee Islands. Differs from the next somewhat in the foliage, but strikingly in the shape of the corolla.

CLERODENDRON (TETRATHYRANTHUS) AMICORUM (*Clerodendron Amicorum*, Seem. in Bonplandia, 10, p. 249): foliis ovali-seu cuneato-obovatis (9–11-pollicaribus) in petiolum brevem attenuatis integerrimis cum ramis subteretibus glabris; cymis multifloris corymboso-paniculatis canescenti-puberulis; corollæ tubo subinfundibuliformi calyce 4-lobo quadruplo lobis ipsis duplo triplove longiori; staminibus modice exsertis. — Samoan and Friendly Islands. Corolla stouter, its tube shorter (at most an inch long) and enlarging upwards, and the limb larger than in the preceding. The tetramerous flowers remind us of Labillardière's genus *Oxera*, of New Caledonia, but in all other particulars it is a *Clerodendron*. Since the above character was drawn up, Dr. Seemann has published the species as a new one, under the same name, comparing it with *C. inerme*, but without noticing the tetramerous character.

NESOGENES EUPHRASIOIDES, A. DC. (*Myoporum?* *euphrasioides*, Hook. & Arn.), which was collected upon several of the Coral Islands,—a plant with much the aspect of *Hedeoma pulegioides*, or of some *Lythrum*,—proves to be no shrub, but probably an annual, and no Myoporineous plant. The anthers are distinctly two-celled, and the ovules are erect. Without doubt it is a true Verbenacea, but I know not any genus which it particularly approaches. The generic character, as corrected and completed, is as follows:—

Char. gen. Calyx obconicus, 10-nervis, 5-dentatus, dentibus triangularibus, post anthesin auctis patentibus. Corolla bilabiata, labio superiori bipartito, inferiori tripartito, lobis rotundatis consimilibus, posticis paullo brevioribus. Stamina 4 fertilia, didynama, cum vestigio filamenti quinti: antheræ biloculares, didymæ, loculis paullo divergentibus (haud confluentibus) basi aristulatis. Discus hypogynus nullus. Ovarium ovatum, biloculare, loculis uniovulatis: stylus terminalis, filiformis: stigma parvum indivisum. Ovula e basi loculi erecta, anatropa. Drupa sicca, nucumentacea, parva, calyce inclusa, epicarpio tenuissimo, endocarpio crustaceo, bilocularis (vel dissepimento evanido unilocularis), disperma vel abortu monosperma. Semen cylindraceum, testa reticulata, albumine parco. Embryo teres: radícula infera cotyledonibus æquilonga. — Herba sesquipedalis, ut videtur annua, hirtello-scabra, caulibus nunc basi lignescentibus, ramis foliosis; foliis oppositis parvulis ovatis basi angustatis in petiolum attenuatis integerrimis, inferioribus quandoque subcrenatis; floribus parvis in axillis sæpissime geminis; pedicellis calyce brevioribus minutissime bibracteolatis mox decurvis; corolla cærulescente?

Myoporineæ.

The ordinal character in the Prodrômus respecting the stamens, “absque vestigio quinti superioris,” disregards Brown’s character, “quandoque rudimentum quinti, raro polliniferi.” It may be indirectly made out that Brown here refers to *Myoporum*, and I suspect that he had a Sandwich Island representative of this group in view, in which the stamens are really isomerous with the lobes of the corolla in all the numerous flowers which I have been able to examine. This character in *M. Sandwicense*, (which has escaped the notice of all preceding observers, except, probably, of Brown, who must have had this plant under examination,) along with the increase in the number of the cells of the ovary, would fully warrant the establishment of a separate

genus. But the fifth stamen is wanting in *M. (Pentacælium) bontioides* of Japan, and in the allied *M. Chinense*. The Japanese species sometimes has the cells of the ovary reduced to four (unless there is a slip or misprint in Zuccarini's detailed description); while, on the other hand, one of the original species, *M. lætum*, Forst.,* has a 3-celled and 3-seeded putamen; and this not by the abortion of a half-carpel, for the ovary in the flower I examined was found to be trilocular with a single ovule in each cell. All this militates against De Candolle's primary division of the genera, and against the validity of his genus *Polycælium* (*Pentacælium*, Zucc.). The alternative evidently now is the establishment of two genera, *Polycælium* and *Pentacælium*, or their reduction to mere sections of *Myoporum*. The latter is, I confidently suppose, the better view, and the species in question may be disposed as follows:—

§ 1. **PENTACÆLIUM** (*Pentacælium*, Zucc.). Ovarium 4–6-sæpius 5-loculare. Stamina 4, didynama.

MYOPORUM CHINENSE. *Polycælium Chinense*, A. DC. Prodr. 11, p. 706. — China.

MYOPORUM BONTIOIDES. *Pentacælium bontioides*, Zucc. Fam. Nat. Fl. Jap. 2, p. 27, t. 3. *Polycælium bontioides*, A. DC. l. c. — Japan.

§ 2. **POLYCÆLIUM.** (*Polycælium*, A. DC. l. c. pro parte.) Ovarium 5–8-loculare. Stamina 5 vel 6, petalis isomera.

MYOPORUM SANDWICENSE (*M. tenuifolium*, Hook. & Arn. Bot. Beech. p. 93, vix Forst. & R. Br. *Polycælium Sandwicense*, A. DC. l. c.): glabrum; foliis oblongo-lanceolatis acutissime vel tenuiter acuminatis integerrimis, inferioribusve nunc parce serrulatis; fasciculis 3–8-floris; pedicellis petiolum subæquantibus; corolla late campanulata ad medium usque 5-fida; staminibus 5; drupa 4–8-loculari. Ludit floribus 6-meris 6-andris, foliis aut 2–3-pollicaribus angustis aut 3–5-pollicaribus multo latioribus. — Sandwich Islands, leg. Menzies, Beechey, Gaudichaud, Douglas, Nuttall (*Prinastrum cauliflorum*, Nutt. in Herb. Hook.), Remy (nos. 461, 462, 463), &c., on almost all the islands. Variable in the foliage, &c. One form is recorded as “a decumbent shrub”; another, as “a tree, forty feet high.” But no mention is made of its wood, which, according to Hooker and Arnott,

* “Stamens 5,” in the generic character of Hook. f. Fl. N. Zeal., is an evident lapsus or misprint.

on the authority of Menzies, has the fragrance of sandal-wood, and was formerly exported as such to China. Stamens all antheriferous and alike, or two of them frequently a little exceeding the others, or with larger anthers. Seed cylindrical : albumen thin, or sometimes wanting. Embryo cylindrical ; the cotyledons as long as the radicle.

Plantaginaceæ.

Notes upon the dimorphism and tendency to diclinism in the flowers of many species of *Plantago* have been published in Man. Bot. N. U. S., the Botany of the Mexican Boundary, and in Silliman's Journal for Nov. 1862, p. 419.

PLANTAGO ORBIGNYANA, Steinh. ex Decaisne, appears to be only an andine variety of *P. hirtella*, a perennial analogue of *P. Virginica*, and which, like that species, occasionally has the long-stamened and open-flowered form fruitful. Of the var. *Orbignyana*, only the form with short stamens and connivent-closed corolla is known. In our specimens, the style projects from the apex of the closed corolla in anthesis ; so that these flowers are not self-fertilized, as has been supposed, but cross-fertilized, as in analogous cases.

PLANTAGO PAUCIFLORA, Lam., Barnèoud, &c. (*P. barbata*, Forst., &c. *P. polymorpha*, Banks & Soland. *P. monanthos*, D'Urv., Hook. f. &c.) — Fuegia. The distinctions between *P. barbata* and *P. monanthos* have been reduced by Dr. Hooker to two ; viz. the want of beard at the base of the leaves in the latter, and the basal portion of the calyx scarcely exceeding the calyx in the former. The character derived from the beard would be expected to break down on consideration of Dr. Hooker's varieties of the two, and of what we know of other species. In fact, antarctic specimens with copious beard or wool, and with broad and toothed leaves, — and even some of Hooker's own, from Hermite Island, with long, narrow, entire leaves, — exhibit the funnel-shaped persistent portion of the capsule after dehiscence of twice or thrice the length of the calyx. Decaisne's distinctions in respect to the ovules and seeds are invalidated by Dr. Hooker's excellent figures, which represent four seeds in each cell of *P. monanthos*. These antarctic forms being evidently all of one species, Forster's name of *P. barbata*, being inapplicable to the whole species and not very much earlier than Lamarck's, may properly enough give place to the latter. I suspect that Dr. Hooker's specific diagnosis has been drawn between the common antarctic species and the following one, confused with

P. barbata of Forster. I have seen no Chilian specimens referable to the latter; but they very probably exist.

PLANTAGO UNCIALIS, Decaisne. (*P. pauciflora*, var. *major*, Barneoud? *P. barbata*, var. *uncialis*, Wedd. *P. andicola*, Gillies in herb. Hook.) — High Andes of Chili, close to the snow. In this the globular-ellipsoidal, 4-seeded capsule debisces below the middle, and the persistent portion is decidedly shorter than the sepals.

PLANTAGO PRINCEPS, Cham. & Schlecht. This remarkable species, of the Sandwich Islands, certainly includes *P. Queleniana* of Gaudichaud (as Chamisso suspected); and I am constrained to append to it the following as varieties, although they appear so different that they would naturally be taken for species. If so, many such are making in the Sandwich Islands.

Var. β . LAXIFOLIA: caule 1–2-pedali minus lignoso; foliis magnis (4–7-pollic.) submembranaceis oblongo-lanceolatis ovalibus seu obovatis basi in petiolum alatum angustatis 7–9-plinerviis, basibus laxe imbricatis; capsula plerumque 4-sperma. — Hawaii, growing among stones by the sea-side, at the northern base of Mouna Kea.

Var. γ . HIRTELLA: foliis præsertim subtus cum pedunculis pilis crispatis hirsutis, petiolis angustis; capsula disperma: cæt. fere præcedentis. — On the tabular summit of Kauai.

PLANTAGO PACHYPHYLLA (sp. nov.): acaulis; caudice crassissimo lanato; foliis crasso-coriaceis ovali-oblongis ligulato-lanceolatisve integerrimis 5–11-nerviis glabratibus vel tomentulosis puberisve scapo multum brevioribus; spica elongata densiflora; floribus basi lanatis (denique sæpius glabratibus); bractea sepalisque ovatis obtusis vel obtusissimis; corollæ lobis ovatis obtusis vel obtusissimis vel post anthesin acutatis; ovulis in quoque loculo 2–4. — Sandwich Islands.

Var. α . MAVIENSIS: latifolia; foliis 9–11-nerviis (cum petiolo brevi lata 5–7 poll. longis $1\frac{1}{2}$ –2 poll. latis) subtus scapisque (pedalibus) lana decidua tomentosis; caudice erecto percrasso. Subsexus masculinus, staminibus (styloque) longe exsertis; ovulis in utroque loculo 2–4 haud gravidis. — Maui, on Mouna Haleakala, alt. 7,500 feet. Aspect of *P. Aucklandica*.

Var. β . HAWAIENSIS: caudice repente minus lanato; foliis ovato-lanceolatis seu latiuscule lanceolatis seu lineari-ligulatis raro denticulatis 5–9-nerviis in petiolum breviusculum vel brevissimum attenuatis cum scapo (1–2-pedali) glabratibus vel hirsutiusculis, tomento sæpius evanido; sepalis plerumque ciliolatis capsula ellipsoidea 4–6-sperma

paullo brevioribus. — Subvar. *GRACILIS*, *longipes*; petiolo gracili 1 – 2½-pollicari lamina lanceolato-oblonga 3 – 5-nervi æquali; scapo gracili; spica laxiflora; capsula oblonga calycem subduplo superante. — Hawaii, on Mouna Kea and Mouna Loa to the elevation of 6,000 to 8,000 feet, and in the environs of the Great Crater. Subvar. *gracilis*, Hawaii, Remy, no. 429.

Var. γ . *KAVAIENSIS*: depauperata; foliis oblongis cum petiolo lato brevissimo 1½ – 2-pollicaribus; spica laxiflora cum scapo gracillimo semipedali: cæt. var. β . — Kauai, on the tabular summit. Aspect rather of *P. eriopoda*.

Barnèoud's *P. Brongniartii* (briefly described from a single specimen of Gaudichaud's collection, and not identified by Decaisne), on account of the narrow and very acute lobes of the corolla and the acute bracts, would appear to be rather a depauperate state of *P. princeps* than any other. Still, from its being ranked with *P. macrocarpa* and with *P. virescens* (which is *P. eriopoda*, Torr.*), and the leaves described as fleshy and obtuse, it may prove to be one of the depauperate forms of the polymorphous species here described.

2. Additional Note on the Genus RHYTIDANDRA. By ASA GRAY.

This genus I established on a flowering specimen in the Feejean collection of the South Pacific Exploring Expedition; and afterwards (in the Memoirs of the Academy, 5, p. 334, in 1854) I indicated its close relationship to *Marlea*. To the characters assigned, which should distinguish it from the latter, namely, the camerate anther-cells, the strictly one-celled ovary, and the bifid style with slender lobes, may be added the thin and deplanate epigynous disk. That of *Marlea* forms a large and globular stylopodium, well described by Endlicher, and figured by Clarke, and so conspicuous that it may have misled Bentham; or else there is some slip in his character, "ovary adhering to above the middle," in the Flora Hongkongensis.

But the object of this note is to state that specimens of *Rhytidandra Vitiensis* in fruit have now been detected among some undetermined

* *Plantago eriopoda*, Torr., includes *P. attenuata*, James in Long's Exped.; *P. lanceolata* γ & β (pro parte), Hook. Fl. Bor.-Am.; *P. virescens*, Barnèoud; *P. Richardsonii* and *P. oblongifolia*, Decaisne; *P. salsuginosa*, Nutt. ined.

plants of the collection. So that the detailed character of the genus may be completed as follows:—

Drupa ovata, subacuminata (ultra-semipollicaris), sarcocarpio tenui, putamine osseo ruguloso. Seminis testa membranacea: albumen carnosum copiosum, per cotyledones tenui-foliaceas orbiculares fere bipartitum: radícula supera cylindrica quam cotyledones dimidio brevior.

3. *Synopsis of the Genus PENTSTEMON.* By ASA GRAY.

PENTSTEMON, Mitchell, L'Her.

Sect. 1. EUPENTSTEMON. (*Pentstemonum* sect. 1–4, Benth. in DC.) Antherarum loculi per anthesin divaricati seu divergentes, usque (in *P. baccharifolio* vix) ad basin dehiscentes, apicibus pl. m. coadunatis.

§ 1. (ERIANThERA, Benth.) Fruticuli vel suffrutices ramosissimi, foliis crasso-coriaceis parvulis. Inflorescentia stricte racemosa, nempe pedunculis fere semper unifloris. Corolla violacea seu purpurea, speciosa, leviter bilabiata, fauce ampliata. Antheræ lana longa densa præditæ! loculis usque ad summum apicem hiantibus, effætæ peltatim explanatæ. Am. Bor.-Occidentales.

1. *P. MENZIESII*, Hook. British Columbia to the Rocky Mountains, and those of California.—On comparison of all the specimens within reach, I confidently conclude that all the genuine members of this section (for *P. frutescens*, Lamb. cannot be of the group) are forms of one species,—for which *P. Menziesii* is the most appropriate name. *P. Scouleri*, Lindl. is the earliest published name under this genus; but that belongs to a form with narrowest leaves and sepals, which other botanists may keep distinct,—until they learn how small reliance can be placed upon the particular shape of the divisions of the calyx in this genus. The sterile filament varies from rather strongly bearded to almost naked. The forms which have been indicated as species are:—

a. *LEWISII*. (*P. Menziesii*, Hook. *P. Lewisii*, Benth. in DC. *Gerardia fruticosa*, Pursh.) Folia elliptica basi attenuata, seu obovato-oblonga, serrato-dentata: calycis segmenta lanceolata vel ex ovato lanceolato-acuminata.—Hartweg's no. 1878 and Bourgeau's from the Rocky Mountains have the broadest sepals, which are also glandular-pubescent.

β. DOUGLASII. (*P. Douglasii*, Hook., spec. fructif. *P. crassifolius*, Lindl. Bot. Reg. 24, t. 16, florif.) Folia integerrima, sæpius obovato-lanceolata: calycis segmenta ex ovato lanceolato-acuminata.

γ. SCOULERI. (*P. Scouleri*, Dougl., Lindl. Bot. Reg. t. 1277.) Folia obovato-lanceolata vel oblanceolata, plerisque argute serrata: calycis segmenta ex lanceolato attenuato-acuminata.

δ. NEWBERRYI. (*P. Newberryi*, Gray, in Pacif. R. R. Exped. 6, p. 82, t. 14.) Folia var. α. cum calycis fere var. γ.: corolla rubro-purpurea? — Dr. Newberry noted the corolla as “crimson.” If really of the red series, I was justified in characterizing it as a new species; but I much suspect that the color is purple. The corolla is that of *P. Menziesii*, somewhat reduced in size.

§ 2. (FRUTICOSI.) Frutices vel suffrutices ramosi (3–6-pedales), ramulis floridis sæpe herbaceis, foliis coriaceis parvis parvulisve subpetiolatis. Inflorescentia paniculata pluriflora. Corolla bilabiata, labio superiore pl. m. arcuato-incurvo, inferiore deflexo vel patente. Antheræ glabræ, usque ad apicem dehiscentes, effortæ explanatæ. Californici.

* *Breviflori*; corolla profunde bilabiata ringente flavescente, labiis tubo æquilongis vel sublongioribus. Folia basi attenuata.

2. P. MICROPHYLLUS, Gray, in Pacif. R. R. Exped. 4, p. 119. Cinereo-puberula; foliis ramealibus primariis deciduis vel ad squamas minimas reductis, fasciculorum lineas 2 tantum longis obovatis retusis integerrimis; sepalis lanceolato-ovatis acutis. — Williams’s Fork of the Colorado, between New Mexico and California. Corolla and stamens unknown. Probably allied to the next. A style that remains indicates a rather short corolla.

3. P. ANTIRRHINOIDES, Benth. Subcinereus, fere glaber, ramossissimus; foliis spathulato-lanceolatis oblongisve integerrimis; pedunculis diphyllis sæpius unifloris; sepalis ovato-rotundis; corolla lutea nuda, labiis amplis; filamentis sterilibus superne dense barbato.

4. P. BREVIFLORUS, Benth. Floribus exceptis glaberrimus; foliis lineari-seu oblongo-lanceolatis argute serrulatis; pedunculis plurifloris; sepalis ex ovato acuminatis aut glabris aut glanduloso-hirsutis; corolla extus glanduloso-barbata flavescente intus purpureo tincta, tubo perbrevis; filamentis sterilibus glabro. — The beard, generally so conspicuous on the summit of the unexpanded corolla, is sometimes almost wholly wanting.

- * * *Longiflori*; corolla (plerumque coccinea) longe tubulosa cylindrica, labiis brevibus, superiore erecto subincurvo, inferiore patente 3-partito.

+ Foliis basi attenuatis.

5. *P. TERNATUS*, Torr. Bot. Mex. Bound. p. 115; Gray, in Pl. Coll. Xant., no. 63, Jour. Bost. Soc. Nat. Hist. Fruticosus, glaber; foliis lineari-lanceolatis ternato-verticillatis denticulatis; sepalis lanceolato-ovatis; corolla "pallide coccinea" pollicari; filamento sterili a basi ad apicem valde barbato.

6. *P. CORYMBOSUS*, Benth. Decumbens; ramulis foliisque oblongis obtusis subintegerrimis pubescentibus; cyma corymbosa terminali; sepalis lineari-lanceolatis; filamento sterili glabro ex Benth. in spec. nostris longitudinaliter parce barbato. — Known only from Coulter's Californian collection, no. 629, and from good specimens gathered in Wilkes's Exploring Expedition.

+ + Foliis basi obtusis vel retusis.

7. *P. CORDIFOLIUS*, Benth. Sarmentosus, etiam scandens, pruinoso-puberulus vel glabratus; foliis ovatis vel subcordatis sæpe denticulatis parce dentatisve scabridis, venis supra impressis; floribus plerumque resupinatis; sepalis ovato-lanceolatis; corolla ultrapollicari coccinea; filamento sterili dense barbato. — "Runs over tall bushes like a *Lonicera*"; and, as the bright scarlet flowers are profuse, it would be a great acquisition to the gardens.

Probably a variety of this, or possibly an allied species, is the plant collected in Cajon Pass by Dr. Bigelow, in Whipple's Expedition, with vestiges of fruit only, which I unfortunately, but very doubtfully, referred to *P. Lewisii*.

§ 3. (AMBIGUL) Suffruticosus, foliis coriaceis, inflorescentia paniculata. Corolla miniata, speciosa, superne ampliata, labiis brevibus, superiore suberecto, inferiore tripartito reflexo. Antheræ glabræ, reniformes, effætæ propter rimam leviter incompletam (nempe imam basim loculorum non attingentam) haud explanatæ.

8. *P. BACCHARIFOLIUS*, Hook. Bot. Mag. t. 4627; Gray, in Bot. Mex. Bound. p. 114. W. Texas, 439, 1479, coll. Wright. A well-marked, showy species; the anthers making a slight approach to the structure in the section *Saccanthera*.

§ 4. (ELMIGERA, Reichenb., sine char.) Herbæ, plerumque glaberrimæ, foliis integerrimis, caulinis sessilibus lanceolatis seu lineari-

bus, paniculis virgatis laxifloris. Corolla coccinea tubulosa, pl. m. bilabiata, labio superiore erecto concavo, inferiore patente vel deflexo. Antheræ glabræ, loculis a basi ad *subapicem* dehiscentibus, apice vero clausis, effœtis ergo haud explanatis. Filamentum sterile nudum.

9. *P. BARBATUS*, Nutt. Elatus, floribundus; corolla eximie bilabiata, labio inferiore deflexo ad faucem vulgo barbato; antheræ loculis (etiam in alabastro juniore divergentibus) maxime divaricatis. — Mexico; common.

β. *TORREYI*. (Gray, in Bot. Mex. Bound. p. 114. *P. Torreyi*, Benth. in DC. Prodr.) Corolla fauce minus barbata vel nuda, labiis vulgo (præsertim superiore) paullo longioribus. — Rocky Mountains in Colorado Territory to Northern Mexico. Clearly a mere form of *P. barbatus*, the name of which was not well chosen. (581, Fendl.; 440, 1474, Wright; 395, Hall & Harbour.)

γ. *WISLIZENI*. (*P. coccinea*, Engelm. in Mem. Wisliz., p. 107.) Pauciflorus, statura facie corollisque superne dilatatis *P. imberbis*, sed loculis antheræ divaricatis. — Chihuahua, Wislizenus. The specimens are quite intermediate between *P. barbatus* and *P. imberbis*, the corolla more bilabiate than in the latter, but less so than in the former, especially than in the var. *Torreyi*, the lobes of the lower lip broader, shorter, and apparently less recurved. The absence of beard in the throat is of small consequence; the strongly divaricate anther-cells assign the plant to *P. barbatus* in preference.

10. *P. IMBERBIS*, Trautv. (*P. Humboldtii*, Don. *Chelone imberbis*, H. B. K.) Sesquipedalis, laxiflorus; corolla superne sensim dilatata, labiis brevibus, inferiore haud deflexo nec recurvo; antheræ loculis diu parallelis (ut videtur nunquam divaricatis). Mexico. Under no. 1274 of Coulter's Mexican collection, I have both this and *P. barbatus*.

§ 5. (SPECIOSI.) Herbæ, plerumque glaberrimæ, foliis intègerrimis, caulinis sessilibus, floribus thyrsoidæo-paniculatis speciosis. Corolla e purpureo seu violaceo cærulea superne ventricosæ-ampliata, limbo breviter bilabiato, lobis rotundatis æqualiter patentibus. Antheræ laxè pilosæ vel hirsutulæ, vel in eadem specie nunc glabræ, loculis divaricatis a basi vix ad summum apicem dehiscentibus, effœtis haud explanatis.

11. *P. GLABER*. (*P. glabra*, Pursh. *P. Erianthera*, Nutt. in Fras. Cat., non Pursh. The latter name frequently inappropriate, not pub-

lished with a character, and applied by Pursh to a different species; so that Pursh's good name has priority, and is altogether to be preferred. *P. Gordoni*, Hook. Bot. Mag. t. 4319.) Glaberrimus; foliis sæpius glaucescentibus, caulinis lanceolatis seu ovato-lanceolatis; sepalis late ovatis margine submembranaceis aut muticis aut acumine nunc brevissimo nunc longiusculo terminatis; filamentis sterilibus apicem versus breviter hirsuto, haud raro in stirpibus tam indigenis quam cultis pilis evanidis glabro. — Upper Missouri to the mountains of Utah and New Mexico.

β. OCCIDENTALIS. (*P. speciosus*, Dougl., Lindl. Bot. Reg. t. 1270.) Fere var. α; foliis caulinis vulgo angustioribus; antheris cum filamentis sterilibus glabris. — Interior of Oregon, in and near the Rocky Mountains.

γ. ALPINUS. (*P. alpinus*, Torr., Benth. in DC. Prodr.) Humilior (4–12-poll.), strictior; sepalis e basi ovata seu oblongo-lanceolata sensim longe acuminatis. — Rocky Mountains, on both sides. (No. 259, coll. Parry.) This has the anthers and the tip of the sterile filament more commonly or more abundantly hairy than in the ordinary *P. glaber*, into which it manifestly passes. The acuminate portion of the sepal green, firm, and marginless.

δ. CYANANTHUS. *P. cyananthus*, Hook. Bot. Mag. t. 4464, raised from seeds from the upper valleys of the Platte, in the Rocky Mountains, I know only from the published figure. I had mistaken it for a large form of *P. acuminatus*, in Botany of Mexican Bound. Survey; but it clearly must stand next to *P. glaber*, var. *alpinus*; from which it appears to differ only in its greater height and robustness, large and dense thyrus, and its broader (cordate-ovate) and acuminate upper cauline leaves. Probably it is no more than a particularly well-grown state of the above plant. All the varieties are showy, and the species is one of the handsomest in cultivation.

12. *P. STRICTUS*, Benth. in DC. Prodr. Glaberrimus, subglaucus, virgatus; caule gracili; panicula angustata; foliis caulinis longe linearibus; floribus vix evolutis fere *P. glabro* sed multo minoribus. — Wind River Mountains, near the sources of the Sweet Water of the Platte, Fremont. The specimen is too incomplete for much investigation. It may prove to be an extreme form of *P. glaber*.

13. *P. FREMONTI*, Torr. & Gray, ined. Pruinoso-puberulus, spithameus et ultra; foliis imis spathulatis, caulinis lanceolatis sessilibus; panicula stricta spiciformi nuda, cymulis approximatis plurifloris brevissime pedunculatis; sepalis oblongo-ovatis acutis margine membranaceis; corolla (9 lin. longa) anguste infundibuliformi vix bilabiata;

antheris parce hirsutis; filamento sterili apice dilatato hinc barbato. — “On the Uinta plains, very abundant and in large patches. June 5, 1844.” Fremont. Clearly of this section, notwithstanding the pruinose pubescence.

§ 6. (GENUINI.) *Herbæ variæ*. Corolla aut modice aut vix bilabiata, labiis lobisve vulgo patentibus. Antheræ glabræ, valvulis haud raro denticulato-ciliatis, loculis a basi ad summum apicem usque rima continua dehiscentibus, effætæ apertæ, plerumque explanatæ.

* Undique glaberrimi glauci (summo caule *P. cæruleæ* quandoque excepto), foliis integerrimis coriaceis, caulinis arcte sessilibus seu amplexicaulibus: inflorescentia thyrsoidæa virgata, pedunculis cymularum plerumque brevissimis seu vix ullis tri- plurifloris: corolla superne pl. m. dilatata, vix bilabiata, lobis patentibus vel patentissimis planis.

+ *Cæruleiflori*; corollis haud pollicaribus læte azureis seu purpureo-cæruleis; filamento sterili apice sæpissime dilatato flavo-barbato.

14. *P. CÆRULEUS*, Nutt. (*P. angustifolius*, Nutt. in Fras. Cat., Pursh.) Spithamæus; foliis lineari-lanceolatis, superioribus apiceque caulis vulgo minutim pubescentibus; sepalis lanceolatis sensim acuminate marginæ sæpius ciliolatis albo-membranaceis. — Upper Missouri and Platte, etc. Nuttall probably included forms of the next species under his *P. cæruleus*, probably with good reason. The pubescence of the stem, not mentioned by Nuttall, is alluded to by Pursh. It is evident in a specimen said to be an original one of Bradbury's, in Rafinesque's, now Mr. Durand's, herbarium, in that of Nuttall, in herb. Acad. Philad. (from the Platte), and in that of Fremont from the Wind River Mountains, in Dr. Torrey's herbarium; — which are the only genuine ones before me. But the same thing, only perfectly glabrous and the sepals less white-margined, is Geyer's no. 154 (*P. cæruleus*, Hook. in Kew Jour. Bot. 3, p. 299); and also Richardson's specimens from the north, on which *P. acuminatus*, β . *minor*, Hook. Fl. Bor.-Am. is partly founded; and these pass insensibly into such specimens as Parry's no. 264, which is undoubtedly a narrow-leaved state of *P. nitidus*, Dougl. So that one ought really to add the next species to *P. cæruleus*, diverse as are the extreme forms.

15. *P. ACUMINATUS*, Dougl., Lindl. Bot. Reg. t. 1295. (*P. nitidus*, Dougl., Benth. in DC. Prodr. *P. secundiflorus*, Benth. l. c. *P. Fendleri*, Gray in Pacif. R. R. Exped. 2, p. 168, t. 5, & in Bot. Mex.

Bound. p. 114, excl. syn. *P. cyananth.*) *Spithamæus* ad sesquipedalem; foliis radicalibus spathulatis, caulinis lanceolatis oblongis ovato-lanceolatis vel præsertim superioribus subcordatis rigidis læte glaucis; thyrso elongato floribundo; sepalis aut ovatis aut lanceolatis corolla 6–10 lin. longa; capsula acutissime acuminata. — Saskatchewan and interior of Oregon, along the mountains and elevated plains to Chihuahua. (No. 576, Fendler; 245 and 463, Wislizenus; 1473, Wright; 258, Parry, a form nearly similar to *P. secundiflorus*, Benth.; 264, Parry, and 390, Hall and Harbour, passing to *P. cæruleus*.) Lindley, in publishing *P. acuminatus*, describes the sterile filament as slightly hairy and hooked at the point, but figures the tip dilated. So I find the tip dilated and more or less yellow-bearded in the only flowering specimens I have from the interior of Oregon, collected by Mr. Spalding. Bentham's character, "filamento sterili filiformi glabro," which has been misleading, I have verified only in Hall and Harbour's no. 385, which in other respects is just *P. secundiflorus*. There is no question about the propriety of reducing all these synonymes to *P. acuminatus*.

+ + *Grandiflori*; corollis sesquipollicaribus speciosissimis; foliis caulinis præsertim superioribus rotundatis amplexicaulibus vel connato-perfoliatis; sepalis haud acuminatis; filamento sterili apice adunco leviter dilatato: cymulis 2–5-floris absque pedunculo communi.

16. *P. GRANDIFLORUS*, Nutt. (*P. Bradburii*, Pursh.) Tripedalis; foliis omnibus distinctis; pedicellis abbreviatis; corolla subito inflata cæcio-cærulea; filamento sterili apice vix barbulato. — Wisconsin and Iowa to Kansas. A very handsome species in cultivation, and the earliest to flower. It is singular that it has not yet been figured. I have never observed the sterile filament bearing a small two-lobed anther, as Nees records in Prince Neu-Wied's Travels; on the contrary, in the plants now for many years cultivated in the Cambridge Botanic Garden, this filament is absolutely wanting in about one blossom out of twenty.

17. *P. MURRAYANUS*, Hook. Bot. Mag. t. 3472. Bi-tripedalis; foliis superioribus floralibusque in laminam orbiculatam connatis; pedicellis gracilibus; corolla sursum modice sensim ampliata læte rubra; filamento sterili glaberrimo. — E. Texas (coll. II. 292, Drummond; 282, Lindheimer, &c.) and Arkansas. In Mr. Durand's herbarium is a specimen of *P. Murrayanus* from T. J. Hale of Wisconsin, said to have been found at Dubuque, Iowa (where Dr. Hor collects *P. grandiflorus*); but I suspect there is some mistake about it.

+ + + *Rubriflori*; corollis vix ultrapollicaribus rubris vel coccineis; foliis inferioribus oblongis, superioribus subovatis seu lanceolatis amplexantibus; caulibus sæpius elatis.

18. *P. CENTRANTHIFOLIUS*, Benth. (Hook. Bot. Mag. t. 5142.) Sepalis lato-ovatis; corolla pollicari kermesina tubulosa superne vix ampliata, limbo brevi æquali; filamentis sterilibus glaberrimis. — California. The corolla is bright carmine, the lobes equal, except that the two upper are united higher, and equally spreading, scarcely longer than the breadth of the throat.

19. *P. PUNICEUS*, Gray in Bot. Mex. Bound. p. 113. Cymulis plurifloris densioribus; sepalis ovatis seu oblongis; corolla pollicari vel minore læte coccinea tubulosa fauce leviter ampliata, limbo amplo subæquali, lobis rotundatis; filamentis sterilibus sub apice barbato. — Arizona.

20. *P. WRIGHTII*, Hook. Bot. Mag. t. 4601. Cymulis paniculæ laxæ virgatæ paucifloris; sepalis oblongis apice patentibus; corolla haud pollicari læte roseo-rubra superne ventricoso-dilatata, limbo amplo, lobis rotundatis patentissimis, filamentis sterilibus hinc longe denseque barbato. — W. Texas and Arizona. Length of the corolla and breadth of its limb about equal.

* * Undique glaberrimus, subglaucus, elatus; foliis crebre seu ovato-lanceolatis coriaceis, caulinis superioribus in laminam amplexicaulem connatis: panicula laxa, elongata, cymulis 3-9-floris pedunculatis: corolla (pollicaris) cæruleo-purpurea, tubo superne inflato, limbo bilabiato, lobis latissimis patentissimis; filamentum sterile glabrum.

21. *P. SPECTABILIS*, Thurber, in Pacif. R. R. Exped. 4, p. 119 (63), & Bot. Mex. Bound. l. c.; Hook. Bot. Mag. t. 5260. — California to W. Texas. (1475, Wright.)

* * * Glabri præter inflorescentiam calyces corollasque minutim viscoso-pubentes; foliis lanceolatis, vel superioribus e basi dilatata amplexicauli ovato-lanceolatis sensim acuminatis integerrimis: panicula laxa, pedunculis paucifloris: corolla sesqui-bipollicaris, lobis subæqualibus patentibus: filamentum sterile fere glabrum. Mexicani.

22. *P. GENTIANOIDES*, Don. (*Chelone gentianoides*, H. B. K. Nov. Gen. & Sp. 2, t. 172.) Corolla violacea, vix sesquipollicaris, supra

calycem usque ad faucem valde ampliata campanulata: pedunculi abbreviati.

23. *P. HARTWEGI*, Benth. (*P. gentianoides*, Bot. Reg. 1838, t. 3; Bot. Mag. t. 3661.) Corolla bipollicaris, coccinea vel sanguinea, superne sensim leviter dilatata tubuloso-infundibuliformis: pedunculi 2 – 3-flori elongati.

* * * * Undique fere glabri; foliis pinnatipartitis, segmentis angusto-linearibus: panicula laxiflora: corolla purpurea, haud pollicaris, superne ampliata, lobis subæqualibus: filamentum sterile apice barbatum.

24. *P. DISSECTUS*, Ell. Bot. 2, p. 129; Chapm. Fl. p. 289. — Georgia.

* * * * * Glabri, vel pruinoso- seu viscoso-puberuli, angustifolii; foliis filiformi-subulatis linearibus vel lineari-spathulatis, omnibus integerrimis; racemo simplici seu panicula virgata laxiflora. (Cf. spp. subsequentis foliis quandoque integerrimis glabris.)

+ Inflorescentia stricte racemosa, i. e. pedunculis unifloris, infimis rarissime bifloris; corolla vix bilabiata.

++ Foliis angustissimis fere filiformibus glabris.

25. *P. TENUIFOLIUS*, Benth. Elatus, ramulosus, foliosus, subpuberulus; racemo elongato laxo; corolla (pollicari purpurea?) superne valde ampliata, lobis brevibus; filamento sterili imberbi. — Mexico.

26. *P. LARICIFOLIUS*, Hook. & Arn. (*P. filifolius*, Nutt. ined.) Semipedalis, cæspitosus; caudicibus crebre foliatis; caulibus floridis gracilibus simplicibus; racemo 4 – 8-floro; corolla (semipollicari purpurea), tubo superne ampliato; filamento sterili barbato. — Utah.

27. *P. AMBIGUUS*, Torr. in Ann. Lyc. N. Y. & Marcy, Rep. t. 16. Subpedalis ad bipedalem, paniculato-ramosus e basi lignescente; foliis inferioribus linearibus basi attenuatis, superioribus subulato-filiformibus vel aceroso-subulatis; racemis laxifloris; corolla ("alba purpureo tineta" 5 – 8 lin. longa), limbo amplo patentissimo pl. m. obliquo; filamento sterili glabro. — Rocky Mountains of Colorado Territory to Arizona. — Forma vera: corollæ tubo semipollicari sæpius incurvo supernè vix dilatato, limbo explanato semipollicem diametro, fauce fere undique hirsutula; filamento sterili quandoque antheram parvam gerente. — To this belong Bentham's var. *foliosus*, Fendler's no. 569 (probably, for the flowers are wanting), 459, &c. of Wislizenus, 1471 of Wright,

742 of Thurber, &c. But some of Wright's specimens, and no. 74 and a part of 15° of Wislizenus's, have the tube of the corolla as short and funnel-shaped as in the following.

β. THURBERI (*P. Thurberi*, Torr. in Pacif. R. R. Exped. 7, p. 15, bot. appx.). Corolla minor, brevior, haud semipollicaris, tubo magis dilatato, fauce lineis 2 barbatis antice instructa. — Here belong Dr. Antisell's specimens from the Burro Mountains, and Thurber's 1056 from Ojo de Gavilan, New Mexico, as described by Dr. Torrey, from Prof. Thurber's notes. The distinctions are well taken; but the specimens mentioned above make me hesitate to admit the species.

++ ++ Foliis lineari-lanceolatis seu lineari-spathulatis sæpius puberulis vel pruinoso-pubescentibus; caulibus basi lignescensibus.

28. *P. GAIRDNERI*, Hook. Fl. Bor.-Am. Spithamæus, basi ramosissimus; pedicellis brevibus oppositis vel alternis; sepalis glanduloso-viscosis; corolla semipollicari; filamento sterili longitudinaliter barbato. — Mountains of the Northwest Coast. The naturalists of Wilkes's Expedition collected a flowering specimen in Washington Territory.

29. *P. DASYPHYLLUS*, Gray in Bot. Mex. Bound. p. 112. Pruinoso-vel subglanduloso-puberulus; caule subsimplici; racemo laxo paucifloro; pedicellis alternis vix bracteolatis; corolla purpureo-cærulea fere sesquipollicari; filamento sterili glabro. — Arizona and New Mexico. (1478, Wright.)

+ + Inflorescentia racemoso- seu virgato-paniculata, pedunculis plerisque 2 – 5-floris; sepalis ovatis; caulibus erectis vulgo simplicibus.

++ Ultrapedalis; pedunculis alternis brevibus 1 – 2-floris; corollis puniceis subpollicaribus.

30. *P. LANCEOLATUS*, Benth. Pruinoso-puberula vel glabella, pedicellis calycibusque subglandulosis; filamento sterili glabro. — Mexico; 184, Hartweg; 57 and probably 441, Gregg. In my specimens of Hartweg's collection, as in others, I do not always find the "pedunculi communes subnulli"; but some of them are uniflorous.

++ ++ Bi-tripedalis; pedunculis oppositis elongatis 2 – 5-floris; panícula quam in cæteris laxiori; corollis "cæruleis" (an purpureis?) superne ampliatis sesquipollicaribus.

31. *P. STENOPHYLLUS*, Gray in Bot. Mex. Bound. p. 112. Glaber, foliis linearibus 3 – 4-pollicaribus, superioribus minoribus angustissimis;

filamento sterili glaberrimo. — Mexico, Cosiquiriachi, Wislizenus, 186. Arizona, 1477, Wright.

++ ++ ++ Semi-sesquipedalis, cum foliis sæpius minutissime pruinoso-puberulus; pedunculis pedicellisque brevibus; corollis purpureis ultra-semipollicaribus, fauce valde ampliata, limbo breviter bilabiato, labio superiore minus patente.

32. *P. VIRGATUS*, Gray, l. c. Caule e basi simplicissimo; foliis linearibus seu lineari-lanceolatis $1\frac{1}{2}$ –4-pollicaribus; panicula elongata angustissima multiflora nunc secunda, pedunculis plerumque oppositis; corolla roseo-lilacina; filamento sterili glaberrimo. — New Mexico; 580, Fendl.; 1476, Wright.

33. *P. LINARIOIDES*, Gray, l. c. Multicaulis e basi suffrutescente, cinereo-pallidus, foliosissimus; foliis (pollicaribus vel brevioribus) inferioribus spathulato- superioribus angustissimo-linearibus, floralibus subulatis; panicula angusta subsecunda; pedunculis omnibus alternis, inferioribus 2–5-floris, superioribus unifloris; corolla pallide cæsio-purpurea, palato barbato; filamento sterili longitudinaliter barbato. — New Mexico and Arizona; 1472, Wright; 331, 1115, Thurber.

+ + + *Axilliflora*, nempe ramis (e caulibus cæspitoso-humifusis) usque ad apicem subæqualiter foliosis.

34. *P. CÆSPITOSUS*, Nutt. in herb. Acad. Philad. (*P. pumilus*, Benth. quoad pl. Fremont., non Nutt.) Depressus, cinereo-puberulus; ramis confertis e basi humifusa vel repente adscendentibus foliosissimis (1–3 poll. longis); foliis lanceolato- seu lineari-spathulatis mucronato-apiculatis aveniis (5–9 lin. longis); pedunculis axillaribus brevibus secundis mox decurvo-patentibus apice folioso-bibracteatis flores 1–3 assurgentes brevi-pedicellatos gerentibus; sepalis e basi latiore marginibus scariosa lineari-lanceolatis foliaceis; corolla (6–9 lin. longa) cæruleo-purpurea tubulosa, tubo superne sensim subampliato intus plicis 2 intrusis percurso, limbo breviter bilabiato, lobis subæqualibus; filamento sterili longe barbato. — Rocky Mountains, Nuttall (a diminutive specimen in herb. Acad. Philad.), Fremont (a poor specimen in herb. Torr.), Parry, Hall and Harbour, coll. 1862 (no. 393), at the Middle Park, also on “rocky ledges of the upper Platte, growing in spreading decumbent patches: flowers blue, with purplish tips, and streaked with pink lines, first found by Mr. J. Harbour.” Parry in litt. Very fine and full specimens (received as this article is going to press) are given in the recent collection above men-

tioned, both of the form gathered by Nuttall, with the leaves only about half an inch long and scarcely a line wide, and of a luxuriant form, with larger leaves, and flowers three fourths of an inch long on longer pedicels. The leaves on decumbent branches are all turned to the upper side, and often falcate, while the peduncles are rigidly turned to the lower side of the branch. The species is a well-marked one, and the most dwarf of the genus.

* * * * * Aut pl. m. pruinoso- seu viscoso-pubescentes, aut serratifolii, aut panicula interrupta cymulis densifloris: inflorescentia sæpius thyrsoides; corolla nunquam coccinea.

+ Boreali-Americani; corollis haud rubris.

++ Filamento sterili longitudinaliter flavo-barbato; corolla superne campanulato- seu infundibuliformi-ampliata parum bilabiata.

a. Foliis lanceolatis subintegerrimis, saltem superioribus floribusque viscoso-pubescentibus; panicula stricta, pedunculis brevibus appressis.

35. *P. PUMILUS*, Nutt. Forte *P. albidus* forma alpina, nana (3-4 pollicaris), pauciflora, foliis caulinis basi paullo attenuatis, corolla glabriscula. — Little Goddin River in the Rocky Mountains, Wyeth. Fremont's specimen, referred here in the Prodrômus, must belong to the preceding species.

36. *P. ALBIDUS*, Nutt. (*P. teretiflorus*, Nutt. in Fras. Cat. *P. viscidulum*, Nees, Bot. Appx. in Neu-Wied. Trav. p. 18.) Subpedalis; foliis majoribus sæpe oblongo- seu ovato-lanceolatis; panicula quasi spicata subverticillatim interrupta cymulis plurifloris vel in depauperatis pauciflora; sepalis lanceolatis viscido-pubescentissimis; corolla $\frac{3}{4}$ -pollicari e purpureo albida, tubo superne sensim modice ampliata, limbo imberbi; barba filamenti sterilis breviuscula subinterrupta. — Upper tributaries of the Missouri to W. Texas.

37. *P. CRISTATUS*, Nutt. (*P. erianthera*, Pursh, non Nutt.) Subpedalis; panicula spiciformi, cymulis 3-4-floris; sepalis lineari-lanceolatis attenuatis hirsutissimis; corolla pollicari violaceo supra calycem late infundibuliformi-ampliata, labio inferiore intus et filamento sterili pilis longis insigniter barbatis. — Upper Missouri to the Rocky Mountains.

38. *P. JAMESII*, Benth. (*P. albidus*, Torr. in Ann. Lyc. pro parte.) Spithamæus ad pedalem, puberulus; foliis lineari-lanceolatis sæpe denticulatis rigidis; inflorescentia præcedentis; sepalis lanceolatis e

basi sat lata gradatim attenuatis viscido-puberulis; corolla ultrapollinari pallide purpurea supra calycem subito inflata campanulata, labio intus vix barbato; filamento sterili minus quam in *P. cristato* barbatus. — Eastern side Rocky Mountains and vicinity, to New Mexico (575, 579, Fendler) and the adjacent parts of Texas. Nearest to *P. cristatus*, from which it plainly differs in the narrower leaves, more abruptly ampliate corolla, shorter and less abundant beard, and the calyx more viscid-puberulent, as in *P. albidus*.

b. Foliis latioribus sæpius serratis, caulinis plerisque amplexicaulibus; panicula vulgo nuda laxiflora.

39. *P. COBÆA*, Nutt. Pedalis, raro bipedalis, viscoso-puberulus; foliis ovatis oblongisve argute serratis vel denticulatis; panicula pauciflora cum sepalis oblongis vix acutis viscoso-pubescente; corolla bipollicari ex albedo purpurascens supra calycem subito inflata late campanulata intus glabra. Kansas to Texas. (142, Lindheimer; 577, Fendler; 1834, Berlandier, depauperate.)

40. *P. DIGITALIS*, Nutt. Elatus (3–5-pedalis), præter flores pl. m. viscosos sæpissime glaberrimis; foliis tantum serrulatis, caulinis (3–6-pollicaribus) lanceolatis vel superioribus ovato-lanceolatis e basi lata sursum sensim attenuatis; thyrsos nudo laxo plurifloro; corolla ultrapollinari alba superne e tubo angusto campanulato-ampliata, lobis brevibus subæqualibus, filamentum sterili parcius barbato. — Illinois to Arkansas, Louisiana, and Georgia.

β. MULTIFLORUS, Chapman, Fl. (*P. multiflorus*, Chapm. ined. *P. crassifolius*, Shuttlew., fide Benth.) is I suppose rightly placed by Dr. Chapman under this species, — a form from the pine barrens of Florida and Georgia, with the corolla smaller and narrower, less abruptly ampliate. But I have not seen sufficient materials.

41. *P. TUBIFLORUS*, Nutt. — judging from the insufficient specimens cited in the Prodrômus (from Herb. Torr.), where the name of “Engelman” should be Leavenworth — is probably a slender variety of *P. Digitalis*, with the corolla less ampliate, tubular-funnel-form, and the sterile filament less bearded. But sufficient materials are not in hand. — Arkansas.

++++ Filamento sterili longitudinaliter saltem secus apicem dilatatum flavo-barbato; corolla minus ampliata (*P. glauco* excepto) evidentius bilabiata. *Cismontani* vel *montani*; inflorescentia haud glomerato-condensata.

- a. Multiflori; panicula thyrsoides vel racemiformis nuda, foliis (caulinis aut argute serrulatis aut subintegerrimis) superioribus ad bracteas parvas diminutis, pedunculis vulgo tri-plurifloris; corollæ labio superiore sæpius parum brevior.

These species with the two preceding, all very difficult of definition in the herbarium, need re-examination in the living state. I have examined fresh flowers only of *P. Digitalis* and *P. pubescens*, — than which no two species are more clearly distinct, although in dried specimens they may not always be readily identified. From the shape of the corolla, *P. glaucus* should also be re-established. And I am obliged to intercalate an unpublished species of Nuttall, *P. humilis*, between the latter and *P. gracilis*, Nutt., here reduced to *P. pubescens*. The two new species which follow are choice fruits of Messrs. Parry, Hall, and Harbour's collection, during the present season, which, with other good materials, have come to hand just in time to find a place in this article as it is passing into the printer's hands (November, 1862).

42. *P. PUBESCENS*, Soland. (*P. lævigatus*, Soland. *P. hirsutus*, Willd. *P. Mackayanus*, Hortul.) Sub-1-3-pedalis, viscoso-pubescent vel fere glaber; foliis caulinis (nunc lineari-nunc ovato-) lanceolatis; thyrsis laxifloris; corolla alba cærulescente vel purpurascens superne sensim paullo ampliata leviter obcompressa sub labio inferiore plicis 2 intrinsecis sursum barbatis percurta, fauce subelata; filamentis sterilibus deorsum longe denseque barbato. — Canada to Florida and Texas. In the fresh flowers the two introrse plicæ of the lower side of the corolla, and the throat somewhat closed by the approximation of the base of the lower lip to the rather fornicate upper one, are characteristic.

β. *GRACILIS*. (*P. gracilis*, Nutt.; Bot. Mag. t. 2945, excl. descr. Graham; Bot. Cab. t. 1541.) Subglaber; foliis caulinis et thyrsis angustatis; corolla vulgo graciliori, plicis haud barbatis. — Saskatchewan to Texas. Clearly this is only a slender variety of *P. pubescens*, with the flowers commonly rather narrower, and its beard (always unreliable in this genus) reduced to some scattered hairs on the lower lip. Intermediate forms abound.

43. *P. HUMILIS*, Nutt. in herb. Acad. Philad. *P. gracili* Nutt. (*P. pubescenti* var. *gracili* supra) maxime affinis, sed vulgo humilior (3-9-pollicaris), foliis pallidioribus, thyrsis etiam strictiore, corolla saturate cærulea brevior (haud ultra-semipollicari) fauce satis ampliata hiantes plicis sub labio inferiore obsoletis. — Rocky Mountains, Nuttall

(a very depauperate doubtless alpine specimen in herb. Acad. Philad.); common about Pike's Peak and vicinity, Parry, no. 257 (Enum. p. 27), Mr. Howard, and in taller specimens than before seen, Hall and Harbour, 1862, no. 387, on low mountains, "an early and very pretty species," confirming its close relationship with *P. gracilis*. Yet this cannot be regarded as a variety of *P. pubescens*.

44. *P. GLAUCUS*, Graham; Lindl. Bot. Mag. t. 1286. Spithamæus ad ultrapedalem, præter inflorescentiam floresque viscosos glaber; foliis subglaucis, (radicalibus subovatis,) caulinis lanceolatis seu basi dilatata ovato-lanceolatis; thyrso subcompacto (sepalis ovato-lanceolatis); corolla pollicari supra basim ventricosam ampliata lilacina seu violacea, fauce ampla hiante, plicis sub labio inferiore (pilis longis parce villosa) vix ullis. — Saskatchewan, or in the Rocky Mountains, Drummond.

Var. β . *STENOSEPALUS*: thyrso brevi compacto; sepalis lanceolatis longe attenuato-acuminatis. *P. glaucus*, Gray, Enum. Pl. Parry, p. 27. Rocky Mountains, about Pike's Peak, Clear Creek, &c., Dr. James in herb. Torr., Dr. Parry, 261, 262, and coll. 1862, distributed by Hall and Harbour, 399. — Corolla, as in the figure *P. glaucus* in the Botanical Register, abruptly much ampliate, almost as much so as that of *P. Digitalis*, but more gibbous, very distinctly bilabiate, the lower lip a little exceeding the upper.

45. *P. HALLII* (sp. nov.). Nanus, 3–5-pollicaris, multiceps, præter inflorescentiam calycesque (occulo armato) minutissime glandulosos glaber; foliis glauco-pallidis integerrimis lineari-spathulatis seu linearibus basi attenuatis; thyrso vel potius racemo simplici 4–10-floro, pedicellis calyce brevioribus; sepalis ovatis oblongisve margine late scariosis sæpius erosis; corolla subpollicari e basi brevissima inflata ventricosam-campanulata cæruleo-purpurea, labiis brevibus subæquilongis, superiori fere ad medium bilobo inferiori trilobo intus glabro, filamentum sterili hinc barbato. — Rocky Mountains near Clear Creek, &c., in the alpine region, coll. 1862, Parry, Hall and Harbour: no. 388 distrib. Hall and Harbour. — A most beautiful species, from the size of the flowers as compared with that of the stem, and their bright color. Corolla nearly an inch long, more inflated than that of *P. glaucus*, the contracted base being very short, decidedly bilabiate, but the lips only 3 or 4 lines long, very deeply colored; the tube appears much paler. Radical and lower cauline leaves one or two inches long, including the narrowed base or petiole, $1\frac{1}{2}$ to 2 lines wide towards the summit, thickish; the floral ones reduced to 6 or 3 lines long, and scarcely at all

dilated at the insertion. Flowers solitary or in pairs in the axils, the short peduncle usually bibracteate, forming a short racemose inflorescence. Beard of the sterile filament short, but copious and extending well down one side. This charming *Pentstemon* may appropriately bear the name of one of its zealous discoverers.

- b. Bi-triflori; caulibus usque ad apicem æqualiter foliatis; pedunculis unifloris plerisque ebracteatis; corollæ tubo vix gibboso, labiis æquilongis.

46. *P. HARBOURII* (sp. nov.). Nanus, 2-4-pollicaris; caulibus multicapitibus pruinoso-puberulis usque ad apicem 2-3-florum æqualiter foliosis; foliis fere glabris crassiusculis obovatis oblongisve obtusissimis integerrimis vel repandis; pedicellis alternis cum calyce subæquilongo viscoso-pubescentibus; sepalis ovatis breviter acuminatis seu lato-lanceolatis margine hand scariosis; corolla purpurea (7-9 lin. longa), tubo cylindræo limbo breviter bilabiato, labio superiori profunde bilobo, inferiore profunde trilobo intus ad faucem hispidobarbato; filamento sterili apice dilatato hinc deorsum barbato. — Rocky Mountains of Colorado Territory, in the high alpine region, no. 396 of Hall and Harbour's distribution; found only by Mr. J. P. Harbour, whose name it should bear. Leaves thickish, glabrous or minutely pruinose, 4 to 8 lines long, 3 to 5 lines wide, sometimes retuse; the uppermost closely sessile by a more or less narrowed base, the lowest, or those of sterile shoots, ovate and tapering into a slender petiole. Pedicels in the axils only of the uppermost leaves, and alternate, in flower $1\frac{1}{2}$, in fruit 2 or 3 lines long. Corolla bluish purple, slightly viscous-pubescent; the tube slightly widening upwards; the lips about 3 lines, the similar and spreading rounded lobes $1\frac{1}{2}$ to 2 lines long; a copious and rather stiff beard in the throat or on the base of the lower lip. Capsule not exceeding the calyx.

++ ++ ++ Filamento sterili apice barbato: corolla manifeste bilabiata, tubo vix aut ne vix ampliato. *Transmontani*, panicula interrupta, cymis multifloris condensatis, floribus pro genere parvis 5-8 raro 9-11 lin. longis.

- a. Serratifolii; foliis ovatis seu ovato-lanceolatis sæpius argute dentatis, caulinis superioribus basi subcordata amplexicaulibus; sepalis vix scarioso-marginatis; floribus minus confertis.

47. *P. OVATUS*, Dougl. Puberulus, latifolius; sepalis ovatis seu lato-lanceolatis; corolla purpureo-cærulea. Oregon to British Columbia.

48. *P. PRUTNOSUS*, Dougl. Pubescens; foliis cæsiis; inflorescentia (sæpe quasi verticillata) et præsertim sepalis (lanceolatis longe attenuato-acuminatis) viscoso-villosis; corolla læte cyanea. — Priest's Rapids of the Columbia River; found only by Douglas, long ago lost from the gardens.

6. *Integrifolii*; foliis glaberrimis fere semper integerrimis, caulinis lanceolatis oblongisve; sepalis saltem marginibus albo-scariosis; palato vulgo barbato; thyrsos spiciformi interrupto sæpius quasi verticillastrifloro.

49. *P. ATTENUATUS*, Lindl. Bot. Reg. t. 1295. Sesqui-bipedalis; foliis raro paucidenticulatis; inflorescentia villosa seu pl. m. viscoso-pubescente; cymis plerisque breviter pedunculatis; sepalis ovato-lanceolatis anguste scarioso-marginatis; corolla ochroleuca vel cæruleo-purpurea ultra-semipollicari. — Lewis and Clarke's or Kooskooskie River. The figure in the Bot. Register depicts the flowers as ochroleucous. Bentham writes, "corolla sulphurea." But in similar specimens collected on the Kooskooskie by the naturalists of Wilkes's Expedition it is noted that the "corolla is blue"; while Hooker remarks that those of Douglas's specimens were purple. The color is probably various. Mr. Spalding's specimens from Clearwater, in the same district, have the inflorescence and calyx varying from rather slightly viscid-pubescent to merely puberulent; the color of the flowers not recorded.

50. *P. CONFERTUS*, Dougl.; Lindl. Bot. Reg. t. 1260. Glaberrimus, semi-sesquipedalis, strictus; floribus dense glomeratis; cymis præter infimas fere sessilibus; sepalis lato-lanceolatis seu ovatis latis-sime albo-scariosis margine sæpius eroso-dentatis vel laciniatis aut acutis aut in acumen sæpe longum viride productis; corolla angusta 5-6 lin. longa, sulphurea. — Interior of Oregon and Rocky Mountains.

β. *CÆRULEO-PURPUREUS*. (*P. procerus*, Dougl., in Bot. Mag. t. 2954; Bot. Cat. t. 1616. *P. Tolmiei*, Hook. Fl. Bor.-Am. 2, p. 97. *P. micranthus*, Nutt. in Jour. Acad. Philad.) Spithamæus ad bipedalem; corolla cæruleo-purpurea. — Plains of the Saskatchewan, and through the Rocky Mountains to the coast range of Oregon and British Columbia. I find nothing beyond the color of the flowers to distinguish this from *P. confertus*; and the name *P. procerus* is singularly inappropriate for a plant like this, never tall, and ordinarily one of the lowest of the genus. The sepals are most variable, and the variations are not in relation with the color of the corolla.

++ ++ ++ ++ Filamento sterili glaberrimo.

a. Serratifolii, confertiflori, panicula stricta multiflora ; corolla parum bilabiata.

51. *P. DEUSTUS*, Dougl. in Bot. Reg. t. 1318. (*P. ilicifolius*, Nutt. ined.). Glaber ; foliis sæpe laciniato- seu pectinato-serratis, caulinis oblongis seu lanceolatis ; cymis pedunculatis, sepalis lanceolatis acuminatis ; corolla flavida semipollicari, tubo parum ampliata. — Interior of Oregon ; a rare species ; but it has been collected by Douglas, Nuttall, and (on the Spokane River) by the naturalists of Wilkes's Exploring Expedition. Also by Dr. Lyall, on the Kootenay River, in 1861. Corolla more slender than in Lindley's figure.

52. *P. HETERANDER*, Torr. & Gray in Pacif. R. R. Exped. 2, p. (9) 123, t. 8. Glaber (calyce minute puberulo excepto), virgatus ; foliis lanceolatis seu lineari-oblongis argute denticulatis ; panicula spiciformi interrupta gracili ; cymulis subsessilibus ; sepalis lanceolatis ; corolla albida semipollicari, tubo parum ampliata ; filamento sterili quandoque antherifero. — Sierra Nevada, interior of California.

b. Subintegrifolii, laxiflori, pedunculis 1-3-floris ; corolla bilabiata.

53. *P. WHIPPLEANUS* (sp. nov.). Pedalis ; caule debili foliisque membranaceis ovatis oblongisve subserrulatis glabris ; panicula parva ; pedunculis plerisque oppositis 1-3-floris ; sepalis lineari-lanceolatis longe attenuatis laxis cum inflorescentia viscoso-pilosis ; corolla pollicari superne valde ampliata bilabiata, labio superiore brevior suberecto bilobo, inferiore trilobo intus parce barbato ; filamento sterili glaberrimo apice dilatato uncinato. — Arroyas in the Sandia Mountains, New Mexico, east of the Rio Grande, Dr. J. M. Bigelow, in Whipple's Expedition, Oct. 1853. Stem slender, apparently diffuse from a decumbent base, leafy. Leaves thin ; the radical ones petioled, 3 inches long ; the cauline 2-1½ inches long, sessile, or the upper partly clasping by the rounded base, ovate-acuminate ; only the floral ones reduced in size, these with the peduncles and flowers more or less viscid-pubescent. Peduncles nearly as long as the floral leaves ; pedicels short. Sepals 5 lines long, very attenuate, even narrower than those of *P. Jamesii* ; the corolla almost as amplate as that of *P. cristatus*, but very distinctly bilabiate, its color not recorded. Except for the beardless filament and broader and thin leaves, this should stand with the above-named species.

++ Mexicani; panicula laxiflora; corollis roseis atro-purpureis violaceis, etc. superne ventricosampliatis; foliis argute serratis vel denticulatis sensim acuminatis.

54. *P. CAMPANULATUS*, Willd. (cum synon. Prodrumi). Præter inflorescentiam pl. m. viscosam glaber; foliis caulinis distinctis lanceolatis ovato-lanceolatis seu linearibus argute serratis; panicula elongata nuda racemiformi secunda; corolla superne aut tubuloso- aut campanulato-ventricosa; filamentum sterili paullo barbato. — Common in cultivation, under various forms.

55. *P. PERFOLIATUS*, A. Brongn. Viscoso-villosus; foliis caulinis ovatis connato-amplexicaulibus denticulatis; panicula interrupta foliosa; filamentum sterili fere glabro.

Sect. 2. *SACCANTHERA*, Benth. Antheræ sagittatæ vel hippocrepiformes, loculis apice confluentibus rima unica deorsum usque ad medium dehiscentibus, basibus saccatis. Transmontani; inflorescentia paniculata. Corolla plerumque speciosa, violacea seu lilacina, superne ampliata, limbo breviter bilabiato.

* Undique viscoso-pubescent, grandiflorus; foliis amplis subserratis, superioribus cordato-amplexicaulibus.

56. *P. GLANDULOSUS*, Lindl. Bot. Reg. t. 1262; Bot. Mag. t. 3688. *P. staticifolius*, Lindl. Bot. Reg. t. 1770. — Oregon.

* * Puberulus vel glaber; foliis argute serratis vel pinnatifidis.

57. *P. VENUSTUS*, Dougl., Lindl. Bot. Reg. t. 1309. (*P. amœnus*, Kunze?) Glaberrimus, erectus; foliis lato- seu ovato-lanceolatis argute dentatis subcoriaceis; panicula thyrsoides laxiuscula; sepalis ovato-lanceolatis; corolla ultrapollinari e tubo angusto superne dilatata, lobis ciliatis; filamentis omnibus superne antherisque parce pilosis rariusve glabris. — Oregon.

58. *P. DIFFUSUS*, Dougl., Lindl. Bot. Reg. t. 1132; Bot. Mag. t. 3645. (*P. serrulatus*, Menzies in Hook. Fl. Bor.-Am.?) Puberulus; caulibus adscendentibus; foliis ovatis seu ovato-lanceolatis superioribus subcordato-amplexicaulibus crebre serratis; panicula sæpius foliosa, cymulis densifloris; sepalis ovatis acuminatis nunc laciniatis; corolla haud pollicari; antheris glabris; filamentum sterili apice barbato. — Oregon to British Columbia.

59. *P. RICHARDSONII*, Dougl., Lindl. Bot. Reg. t. 1121; Bot. Mag. t. 3391; Bot. Cab. t. 1641. (*P. laciniatum*, Nutt. in herb. Acad.

Philad.) Fere glaber ; caule sæpius ramoso ; ramis patentibus ; foliis ovato-lanceolatis seu angusto-lanceolatis incisus vel laciniato-pinnatifidis, ramealibus sæpe alternis ; panicula laxa ; corolla pollicari violacea ; filamentis sterilibus apice parce barbato. — Oregon. *P. argutus*, Paxt., of the gardens appears to be a form of this, or a hybrid between it and the foregoing species.

60. *P. TRIPHYLLUS*, Dougl., Lindl. Bot. Reg. t. 1245. Fere glaber, ramosus ; foliis lanceolatis seu linearibus paucidentatis pinnatifidisve rigidulis, inferioribus ternis vel quaternis, superioribus quandoque oppositis, ramealibus nunc alternis ; panicula laxa foliosa ; corolla semipollicari violacea superne parum ampliata ; filamentis sterilibus superne dense barbato. — Oregon to British Columbia.

* * * Glaberrimus vel pubero-glandulosus ; foliis integerrimis ; filamentis sterilibus apice complanato glaberrimo vel glabriusculo ; pedunculis paucis gracilibus 3 – 6-floris.

+ Corolla semipollicari (cærulea) superne parum ampliata ; antheris glabris secus rimam minute denticulatis.

61. *P. GRACILENTUS*, Gray in Pacif. R. R. Exped. 6, (Bot.) p. 83. — Mountains of North California, Dr. Newberry. Lower leaves lanceolate, attenuate into slender petioles, the upper linear, attenuate at the base.

+ + Corolla ultrapollicari superne infundibuliformi-ampliata, limbo leviter bilabiata ; antheris secus rimam hirtello-ciliatis basi aut hirsutis aut glabris.

62. *P. HETEROPHYLLUS*, Lindl. Bot. Reg. t. 1809 ; Bot. Mag. t. 3853. Glaberrimus vel pruinoso-puberulus, vix glaucus ; foliis caulinis lineari-lanceolatis vel anguste linearibus basi attenuatis ; racemo virgato, nempe pedunculis unifloris raro bifloris ; corolla rubro-purpurea. — California. It is to be hoped that the color of the flowers may hold constant in this species ; for there are specimens which, in the shape of the leaves and in the inflorescence, in the herbarium appear quite ambiguous between this and the next species.

63. *P. AZUREUS*, Benth. Pl. Hartw. p. 327, no. 1819. (*P. glaucifolius*, Gray in Pacif. R. R. Exped. 6, l. c. *P. Jaffrayanus*, Hook. Bot. Mag. t. 5045, forma latifolia.) Glaberrimus, glaucus ; foliis caulinis anguste aut lato- vel ovato-lanceolatis, inferioribus nunc spatulato-oblongis, superioribus arcte sessilibus e basi lata subcordato-ovatis seu ovato-lanceolatis ; panicula virgata ; pedunculis 1 – 3-floris : corolla

pulcherrime azurea, tubo basi rubro-purpureo. — California. The above names all evidently belong to one species, variable as to the foliage, of which the *P. azureus* of Hartweg's collection represents the narrowest-leaved state, and *P. Jaffrayanus* of the Botanical Magazine the broadest.

64. *P. LÆTUS*, Gray in Jour. Bost. Nat. Hist. Soc. Subpedalis, pube brevi molli glandulosa cæsio-pruinosis; cat. fere præcedentis. — Fort Tejon and vicinity, Xantus, Wallace. This is likely to be a glandular-downy variety of *P. azureus*.

Species incertæ seu vix cognitæ.

P. FRUTESCENS, Lamb. in Trans. Linn. Soc. 10, p. 259, t. 6. That this was collected in the Ural region (in the Government of Perm, by Georgi, 1773) — far away from its known congeners — seems to be made out by the ticket in Willdenow's herbarium, cited by Ledebour (Fl. Ross. 3, p. 222). So that Lambert was probably misled in some way as to the habitat "Kamtschatka and Unalashka"; and my memoranda made in 1839 enable me to certify that there was no specimen in Lambert's herbarium to authenticate Pursh's habitat, "On the Northwest Coast, *M. Lewis*." Lambert's figure makes it clear enough that the species does not belong to the section *Erianthera*.

P. canosobarbatum, Kellogg in Proceed. Calif. Acad. Nat. Sci., Sept. 1859, (which is translated as meaning Gray-bearded Pentstemon,) I cannot make out.

P. rostriflorum, Kellogg, l. c., with cream-yellow flowers, is equally unknown to me.

Saccularia Veatchii, Kellogg, l. c., from Cerros Island, off California, of which two flowers were communicated to Dr. Torrey, one of them showing a small sterile filament, is probably a *Russelia*.

Addenda.

P. MENZIESII (p. 56), var.? *LYALLI*: ramis (an caulibus?) herbaceis virgatis sesquipedalibus; foliis lanceolatis tenuioribus elongatis (vix coriaceis 2–3½ poll. longis); cat. *γ. Scouleri*. — Between Fort Colville and the Rocky Mountains, Dr. Lyall, ex herb. Hook. A most remarkable form, if not a distinct species.

Dr. Lyall also collected true *P. acuminatus*, Dougl., on the Walla-walla, with the dilated tip of the sterile filament bearded, as figured by Lindley, — and further north he obtained the rare *P. pruinosis*, Dougl.

4. *Revision of the North American Species of the Genus*
CALAMAGROSTIS, Sect. *DEYEUXIA*. By ASA GRAY.

The species of *Calamagrostis* which possess the rudiment of a second flower (*Deyeuxia*, Kunth.), that have as yet been detected in Eastern North America, I can discriminate as follows :—

* *Panicle loose and open even after flowering, and the (mostly purpletinged or lead-colored) strigose scabrous glumes not closing in fruit: hairs of the base of the flower about as long as the hyaline lower palea or sometimes a little shorter, not surpassed by those of the rudiment; awn slender, straight, about equalling the palea. Leaves flat; culm tall.*

1. *C. CANADENSIS*, Beauv. Glumes ovate-lanceolate, acuminate, barely a line and a half long; awn very delicate, not exceeding the hairs of the flower.—Subarctic America (from Bear Lake) and throughout Canada to Pennsylvania and New Mexico above Santa Fé (Fendler, 957).

2. *C. LANGSDORFFII*, Trin. Glumes lanceolate or oblong-lanceolate, attenuate-acuminate, $2\frac{1}{2}$ to 3 lines long, often cinereously strigose-scabrous; awn stouter and often slightly exceeding the palea.—Labrador and Newfoundland to Behring Straits, Sitcha (*C. strigosa*, Bongard), and south to the White Mountains of New Hampshire in the alpine region (W. Boott), Santa Fé, New Mexico (Fendler, 969), and Oregon (Tollmie, Nuttall, *C. Columbiensis*, Nutt. in herb., &c.). Also Greenland (Wormskiold, fide spec. ex herb. Lehmann.); Scandinavia (*C. elata*, Blytt. *C. phragmitoides*, var. *elata*, Anderss.,—and it has the aspect of the last-named species, but the rudiment is manifest); Russia; and Siberia (*C. purpurea*, Trin., &c.). *C. hirtigluma*, Steud., is certainly this species, but not *Arundo Grælandica*, Schrank. *C. Langsdorffii* has been much confounded with *C. strigosa*, perhaps even by Wahlenberg himself; whose *Arundo strigosa* would seem from the original figure and description to be the *C. strigosa* of Hartmann (*C. Hartmanniana*, Fries), while all recent Scandinavian authors take it to be another, closely related, strict-panicled species, and from Wormskiold's herbarium we have the open-panicled and long-haired *C. Langsdorffii* under this name. The latter may be what Wahlenberg communicated to Bongard. At least, spikelets received by me from herb. Hook., as "*C. strigosa*, Sitcha" (whether from Bongard is not stated), belong to *C. Langsdorffii*.

- * * *Panicle strict, its branches short and erect or appressed after flowering, and the glumes mostly closed: lower palea membranaceous or even of nearly as firm texture as the glumes, scabrous: awn stouter.*
- + *Hairs of the base of the flower copious, nearly equalling or only about one third (or rarely one half) shorter than the thin-membranaceous lower palea, not surpassed by those of the rudiment: awn straight or slightly bent, barely exceeding the palea. Leaves narrow and mostly inclined to be involute. Northern and Arctic species, also European.*

3. *C. STRIGOSA*, Wahl., under *Arundo*, according to Fries, Andersson, &c. Glumes lanceolate and gradually subulate-acuminate, considerably exceeding the flower, $2\frac{1}{2}$ to 3 lines long, scabrous on the keel; awn from or below the middle of the palea. — Referring to the remarks under the preceding species, I have only to add, that I have never seen an American or even a Greenland specimen of *C. strigosa*, as understood by Fries (Herb. Norm.) and all recent Scandinavian botanists, but have drawn the character from specimens of Fries and Blytt. The Canadian specimen mentioned by Grisebach in *Flora Rossica* probably belongs, like the Sitcha plant, to *C. Langsdorffii*, which, in the unexpanded state, might be confounded with it. The rudiment of the second flower, in all the specimens examined, is short and wholly or almost naked!

4. *C. LAPPONICA*, Trin. Glumes oval-ovate or lanceolate-ovate and short-acuminate or acute, about 2 lines long, little exceeding the flower; awn from slightly or much below the middle of the palea (hairs scarcely or nearly one half shorter than the flower). — Labrador and Greenland (*C. Grænlantica*, Kunth.), and Arctic sea-coast. Lower Canada, Pursh, *Canad. Herb.*!

5. *C. STRICTA*, Trin. Panicle larger and more lobulate, the spikelets more numerous, smaller (about a line and a half long), and more crowded than in the preceding; glumes lanceolate- or ovate-oblong, obtuse or acute; awn from the middle of the palea or lower. — Canada to the Arctic regions, the Rocky Mountains, &c. Spikelets mostly (but not always) larger than in the Scandinavian plant. Ledges at Willoughby Lake, N. Vermont, W. Boott: a rather luxuriant form, with spikelets nearly two lines long, resembling *C. chalybæa*, Fries, being to *C. stricta* what that is to *C. Lapponica*. Indeed, these two species appear to run together.

+ + *Hairs of the base of the flower slightly or one half shorter than the membranaceous lower palea and commonly surpassed by those of the rudiment: awn stout, divergent or bent when dry, but not twisted, not surpassing the glumes. Culms tall: leaves broad and flat. Eastern United States.*

6. *C. CONFINIS*, Nutt. Panicle elongated, its rather slender branches spreading in anthesis but soon appressed; glumes oblong-lanceolate and very acute, 2 lines long; hairs copious, slightly or one third shorter than the thin-membranaceous lower palea, which bears an awn much below its middle; grain glabrous.—In swamps, Pennsylvania and New York.

7. *C. NUTTALLIANA*, Steud. (*C. coarctata*, Torr., not of Kunth under *Deyeuxia*.) Panicle contracted and spike-like; glumes lanceolate and subulately long-acuminate, serrulate-scabrous on the keel, fully 3 lines long; hairs of the base of the flower scanty and barely half the length of the chartaceous-membranaceous and keeled lower palea on the dorsal side, longer on the other side, where they nearly equal those of the copious tuft at the summit of the otherwise naked rudiment; awn from half-way between the middle and the tapering summit of the palea; grain crowned with a bearded tuft.—Moist grounds, Massachusetts to North Carolina.

+ + + *Hairs of the base of the flower short and commonly not copious, not reaching to the middle of the lower palea, at least on the lower side of the flower: awn from towards the base of the firm-membranaceous palea, mostly bent or diverging above, spirally twisted when dry. Leaves usually flat.*

8. *C. PORTERI*, n. sp. Leaves broadly linear, a woolly-bearded ring at the junction with the sheath; panicle elongated, linear, with the branches appressed; glumes lanceolate, barely acute, pale, and rather scarious, 2 or $2\frac{1}{2}$ lines long; hairs of the flower and of the short rudiment scanty, nearly equal in length on the upper side of the flower and attaining about its middle, very short or wanting on the lower side; awn equalling the palea, suprabasilar, twisted.—Huntingdon County, Pennsylvania, at Pulpit Rocks, and between Alexandria and Huntingdon, in the mountain region, on wooded and dry hillsides, Aug. 1862, Prof. Thomas C. Porter. Stems 2 to 4 feet high. Leaves 2 to $3\frac{1}{2}$ lines wide, tapering gradually to a slender point. Panicle 5 to 6 inches long, not purplish. This is an American analogue of *C. varia* or *montana* of Europe; but in that the glumes are more acute, the beard of the rudiment far longer and more copious, and the awn longer.

9. *C. SYLVATICA*, DC. Panicle contracted; glumes ovate-lanceolate, sharply acuminate, about 3 lines long; hairs only one fourth of the length of the flower, but the plumose elongated rudiment with its hairs reaching to or much above the middle of the flower; awn suprabasilar, twisted, exceeding the palea and the glumes. — Arctic coast (*C. purpurascens*, R. Br.), Saskatchewan (a specimen in Bourgeau's collection has the second flower sometimes imperfectly, sometimes perfectly formed), &c., and Rocky Mountains.

10. *C. PICKERINGII*, Gray, Man. ed. 2. (*C. sylvatica*, var. *breviseta*, ed. 1.) Panicle pyramidal, contracted after flowering, purplish; glumes ovate-oblong, obtusish or obtusely somewhat pointed, 2 lines or less in length; hairs, both those at the base of the flower and of the short rudiment, scanty and very short, only one fourth or fifth the length of the very obtuse lower palea, which bears half-way between the middle and the base a stout and straight or bent (but not twisted) awn not surpassing the flower. — White Mountains of New Hampshire, in the alpine region, Aug. — Sept. A luxuriant and smaller-flowered variety of this was gathered far below the alpine region, at Echo Lake, Franconia, by Wm. Boott, Esq.; its spikelets only a line and a half long. Hairs wanting at the base of the back of the lower palea, as in allied species. Rudiment always less than half, and often only a quarter of the length of the flower, and sparingly plumose with short hairs, or merely tipped with a few such hairs, or not rarely perfectly naked!

From the western side of North America are some forms of *Calamagrostis*, as yet imperfectly known to me. The species in the books peculiar to that region are perhaps reducible to two, viz.: —

C. ALEUTICA, Bongard. Some spikelets from an authentic specimen, supplied from the Hookerian herbarium, show that I had correctly (in Proceed. Acad. Philad., July, 1862, p. 334) referred here the *C. pallida*, Nutt. in herb. Acad. Philad., a name changed by Mr. Buckley to *C. albicans*. The species is a well-marked one, with spikelets 3 lines or more in length, the equal palea of nearly the same texture as the glumes, short hairs at the base of the flower, and a short straight awn. From the character in the Reliquiæ Hænkeanæ I infer that *Deyeuxia Nutkaënsis*, Presl., is the same thing.

C. DESCHAMPSIOIDES, Trin. Judging from the figure of Trinius and the description in the Flora Rossica, to this may perhaps belong one of Nuttall's species published by Mr. Buckley under the name of *C. rubescens*.

Mr. Agassiz made a communication intended to show:—

That the principle generally received by geologists, that difference of fossils indicates difference of age, and that identity of fossils is essential to synchronism of deposits, is erroneous; for different areas of the same geological epoch would exist under different external conditions, and would therefore contain very different fossils,—just as the faunæ of the present day differ widely from each other in different parts of the earth; also that the so-called tertiary age is made up of at least ten distinct ages, with faunæ specifically distinct from each other. If the principle thus far advocated has led to correct results, it is chiefly because the researches upon this subject have been carried on within one and the same zone in Europe and America. With the extension of our comparisons over wider areas of the earth's surface, it becomes evident that the faunæ of past ages, even when contemporary, may differ, according to their geographical relations, in a way similar to the differences existing among the faunæ of the present period.

Five hundred and fourteenth meeting.

November 12, 1862. — STATUTE MEETING.

The PRESIDENT in the chair.

The Recording Secretary read letters received since the previous meeting.

Cyrus M. Warren, of Boston, was elected a Fellow, in Class I., Section 3;

Alexander E. R. Agassiz, of Cambridge, in Class II., Section 3;

William P. G. Bartlett, of Cambridge, in Class I., Section 1;

George Searle, of Brookline, in Class I., Section 1.

Dr. C. T. Jackson presented a paper on the extraction of the cobalt oxide from the iron pyrites of Brockville, Canada West, by Thomas Macfarlane. He also enforced the great importance of a careful examination of the pyrites of this country for nickel, on account of the value of this metal at the present time as an element in the currency.

Dr. B. A. Gould presented some copies of his paper recently published by the Coast Survey, and entitled, "*Standard Mean*

Right-Ascensions of Circumpolar and Time Stars, prepared for the use of the U. S. Coast Survey." He stated that

This pamphlet contains, — 1st, the right-ascensions and declinations, for the Mean Equinox of 1855.0, of 48 Circumpolar Stars, or stars within 25° of North Polar Distance, together with their proper motions and the coefficients of all those terms of the precession which became appreciable within one hundred years; 2dly, the right-ascensions, proper motions, annual precessions, and secular variations of 128 time-stars, or stars favorably situated for determining time within the latitude of any portion of the United States; 3dly, the corresponding mean right-ascensions of each of these 176 stars for the beginning of every year, from 1851 to 1863 inclusive. To the fundamental tables are also appended the logarithmic constants for reducing from the mean to the apparent equinox, and their annual variations. The positions of these stars were originally computed in 1854, but have repeatedly since that time been revised and corrected by the introduction of new observations; and they seem to be the best yet attainable, inasmuch as all observations of a high character which were to be found on record have entered into the determination. For each catalogue or series of observations employed, the reduction to the zero of Argelander's *Abc* catalogue has been carefully deduced by the method of least squares, having regard both to constant terms and to terms which are functions of the right-ascension or declination; the materials being derived, 1st, from collation of all stars common to Argelander's catalogue and to the authority under investigation; and 2dly, where this means was sufficient, by indirect comparison through the medium of other catalogues.

The star-lists in their present form were essentially completed early in 1861, although a few observations have since then been incorporated with the other materials. In March, 1862, manuscript copies were furnished by Professor Bache to the Superintendents of the Washington Observatory and of the American Nautical Almanac, on their respective applications, and these places adopted for use by them; so that the fundamental places or zeroes employed for determining time and right-ascensions are now identical in all the national scientific institutions.

The equinox of 1855.0 was originally selected, because this date, being the semi-decade nearest to the time of computation, was then the most convenient. By a happy coincidence, this epoch is precisely a century later than the epoch of Bradley's observations, as reduced by

Bessel in the *Fundamenta Astronomiæ*, the earliest trustworthy telescopic determinations; and this circumstance has seemed a sufficient reason for leaving the original epoch of computation unchanged, although a date nearer to the present time of publication would of course appear to be more natural. The small pamphlet now submitted contains only the last results of the laborious and protracted investigation which has long been prepared for the "Records and Results of the U. S. Coast Survey," of which it constitutes one volume. This work has been long delayed, in spite of the efforts of the Superintendent, and the present war threatens to postpone the publication for an indefinite period. It has now seemed desirable to the Superintendent of the Survey for many reasons to circulate in type the results long since disseminated in manuscript. Dr. Gould added, that, while the places here given were, in his belief, the best yet attainable, — nevertheless, since each new measurement furnished new materials for the research, he proposed to continue the work hitherto accomplished, by the periodic incorporation with the old data of the results of recent observation, that the limits of possible error may be reduced to a minimum, and that astronomers may hereafter find ready access at all times to the best positions for fundamental stars which the condition of practical astronomy affords.

The committee to whom was recommitted the proposed draught of amendments to the Statutes and Standing Votes reported them back to the Academy for enactment, recommending, however, the adoption of the amendment of the draught of the Statute, Chapter IV., Section 2, essentially as proposed at the former session.

The propositions being severally put to vote, the following were duly enacted as Statutes: —

Chapter III., Section 3. *The President, or in his absence the next officer as above enumerated, shall nominate members to serve on all the Committees of the Academy which are not chosen by ballot.*

Chapter IV., Section 1. *At the Annual Meeting there shall be chosen the following Standing Committees, to serve for the year ensuing, viz.:*

2. *The Committee of Finance, to consist of the President, Treasurer, and one Fellow chosen by ballot; who shall have charge of the investment and management of the funds and trusts of the Academy. The general appropriations for the expenditures of the Academy shall be moved by this Committee at the Annual Meeting, and all special appropriations*

from the general and publication funds shall be referred to or proposed by this Committee.

3. *The Rumford Committee, of seven Fellows, to be chosen by ballot; who shall consider and report on all applications and claims for the Rumford Premium; also on all appropriations from the income of the Rumford Fund, and generally see to the due and proper execution of this trust.*

Chapter VI., Section 4. *All moneys which there shall not be present occasion to expend shall be invested by the Treasurer, under the direction of the Finance Committee, on such securities as the Academy shall direct.*

Chapter VII., Additional Section:—

1^a. *To all books in the library procured from the income of the Rumford Fund, the Librarian shall cause a stamp or label to be affixed, expressing the fact that they were so procured.*

The following additional Standing Vote was enacted:—

2^a. *Books, publications, or apparatus shall be procured from the income of the Rumford Fund only on the certificate of the Rumford Committee, that they, in their opinion, will best facilitate and encourage the making of discoveries and improvements which may merit the Rumford Premium.*

Also voted, That the Statutes and Standing Votes as now amended be printed under the direction of the Committee on Publication.

Five hundred and fifteenth Meeting.

December 10, 1862. — MONTHLY MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read letters from Messrs. Bartlett, Searle, and A. Agassiz, in acknowledgment of their election as Fellows.

Dr. Hill read a paper "On a Geometrical Illustration of several Algebraical Theorems concerning the Roots and Powers of Monomials."

Professor Peirce showed that some modifications of the geometrical figure would render it capable of illustrating a still wider range of algebraical theorems.

Professor Hitchcock read the following paper, which was illustrated by specimens, casts, and drawings of the footprints described.

Supplement to the Ichnology of New England. By EDWARD HITCHCOCK.

Professor Hitchcock stated that this paper was the result of the examinations he had made in preparing a descriptive catalogue of the large collection of fossil footmarks in Amherst College. He had thus become satisfied that some of the species of footmarks described in his *Ichnology of New England*, published by the government of Massachusetts in 1858, should be given up, that some others were doubtful, but that a still large number of new ones must be added to the list. The paper also contains important additions to the *Ichnology* in respect to insect tracks, and points out a supposed error, as to some of the larger tracks, into which the author and others have fallen, whose correction may essentially modify our views as to the nature of the animals.

1. *Species of the Ichnology not reliable.*

BRONTOZOOM ISODACTYLUM.	PTILICHNUS TYPOGRAPHUS.
PLATYPTERNA GRACILLIMA.	PTILICHNUS PECTINATUS.
BATRACHOIDES ANTIQUIOR.	GRAMMEPUS UNIORDINATUS.

2. *Species of doubtful Character.*

AMBLYONYX GIGANTEUS.	PLATYPTERNA DEANIANA.
AMBLYONYX LYELLIANUS.	TRIDENTIPES UNCUS.
ARGOZOOM REDFIELDIANUM.	

3. *New Species.*

1. ANOMÆPUS INTERMEDIUS.
2. ANOMÆPUS MINIMUS.

This genus in the *Ichnology* is classed among the *Marsupialoids*, but called also *Ornithoid*, combining as it does characters found now in the Marsupials and Birds. Two species are described in the *Ichnology*, — *A. major* and *A. minor*. Two others are now added.

3. ANISOPTUS GRACILIOR. The Anisopus is also regarded in the Ichnology as *Marsupialoid*; but also *Loricoid*.

4. BRONTOZOOM ISODACTYLUM. The *B. isodactylum* of the Ichnology is probably identical with *Anomæpus intermedius*, and therefore stricken out. The present is substituted, — a much larger species.

5. GRALLATOR PARALLELUS. Having the form of *Grallator cursorius*, but much larger, yet with even a smaller stride.

6. HARPEDACTYLUS CRASSUS. } Beautiful species, which I can

7. HARPEDACTYLUS GRACILIOR. } hardly doubt belong to this genus.

8. TRIHAMUS ELEGANS. I make of this a new genus (*Trias* and *Hamus*, *three hooks*) as well as species, because I cannot refer the very distinct specimen which contains it to any genus of the Ichnology. It seems to have been a biped, so far as we yet know.

9. EXOCAMPE MINIMUS. Differs from the *E. ornata* of the Ichnology chiefly by its minuteness.

10. APATICHNUS CURVATUS (No. 4 $\frac{1}{2}$ of the Cabinet). A fine track, doubtless undescribed; but I am not sure it is an *Apatichnus*, for as yet we find no fore-foot.

11. GRAMMICHNUS ALPHA. The Ichnology has two species of *Grammepus*, which means that the *foot* has the form of letters: *Grammichnus* implies that the *track* has that form. This is the true idea; and I should prefer if *Grammepus* were stricken out. Yet the *Grammichnus Alpha* is totally unlike the *Grammepus* of the Ichnology. It has the appearance of a repetition of the capital A impressed cross-wise upon the trackway. But I cannot imagine even by what class of animals it was made.

12. AMPELICHNUS SULCATUS. This is the same as the *Grammepus uniordinatus* of the Ichnology. But a more careful examination shows it to be totally unlike the *Grammepus erismatus*. It is named from a not very close resemblance to a vine with its clusters (*ἄμπελος*). I cannot refer it to any known class of animals.

13. LUNULA OBSCURA. This new genus is characterized by lunate impressions along the sides of an axis; and perhaps they are made by a Myriapod. But the specimens are rather indistinct.

14. BISULCUS UNULATUS.

15. TRISULCUS LAQUEATUS. The Ichnology has a *Unisulcus*. The etymology of the above two new genera will show their essential character. They were doubtless Annelids.

Insect Tracks.

Though the Ichnology does not undertake to distinguish between the tracks of Insects, Crustaceans, and Myriapods, yet it describes six species that had six feet with single linear extremities, and we can hardly doubt that these were insects. It also describes in the same group six other analogous species, some of which had apparently only two and others four feet. Yet on one or two specimens there appeared, occasionally at least, tracks of at least a second set of feet; and the suggestion was made, that probably they had the six feet of insects, but only two or four of them usually left an impression. Several specimens recently obtained completely confirm this view. It is exceedingly probable, then, that at least fourteen species of insect tracks are described in the Ichnology. To these may be added two new ones, which follow, one of which seems to be a new genus.

16. *BIFURCULAPES CURVATUS*. The tines of the fork are so curved here as to be distinctive of a species.

17. *HARPEPUS CAPILLARIS*. The principal feet are beautifully curved, and the mud at the larger end of the track is crowded into a bunch, that may be regarded as a short handle to the sickle (*ἄρπη*, a sickle). The curve of the sickle is as fine as a delicate hair: hence the specific name.

The other fourteen species are the following (see Ichnology):—

<i>ACANTHICHNUS CURSORIUS</i> .	<i>HEXAPODICHNUS MAGNUS</i> .
<i>A. SALTATORIUS</i> .	<i>H. HORRENS</i> .
<i>A. TARDIGRADUS</i> .	<i>BIFURCULAPES LAQUEATUS</i> .
<i>CONOPSOIDES LARVALIS</i> .	<i>B. TUBERCULATUS</i> .
<i>GRAMMEPUS ERISMATUS</i> .	<i>B. SCOLOPENDROIDES</i> .
<i>LITHOGRAPHUS HIEROGLYPHICUS</i> .	<i>B. ELACHISTOTATUS</i> .
<i>L. CRUSCULARIS</i> .	<i>COPEZA TIRREMIS</i> .

If these conclusions are correct, they show the presence, during the Connecticut River sandstone period, of numerous insects, and thus the probability is increased that this rock is Jurassic rather than Triassic; for of the species of fossil insects described by Bronn, only nine occur below the oölite, and one hundred and nineteen in that formation.

Peculiar and Undetermined Specimens.

18. *SCALICHNUS INCERTUS*.

These impressions are very distinct; and if we look only at the

ladder-like rows, of which the specimen shown contained several, we should hardly doubt that they are tracks; but the whole slab is covered with analogous markings, and there are some rows of them that seem as if of vegetable origin. Though a name is for convenience attached to these specimens, yet it is extremely difficult to make up one's mind as to their character.

19. PERHAPS CRUSTACEAN TRACKS.

Some large and remarkable slabs were described under this head. On these slabs, the largest three and a half by four and a half feet, may be noticed the following:—

1. Several perfectly straight grooves or furrows, perfectly parallel, sometimes not half an inch apart, resembling drift furrows.

2. Numerous rows of impressions, not less certainly than thirty-five, running across the slab, nearly parallel to one another and to the grooves, but sometimes intersecting at a small angle, and apparently independent of the grooves.

3. Circular dents, as if made by a blunt stick, but nearly equidistant; sometimes elongated and linear, sometimes boot-shaped, sometimes with a trifid arrangement in equidistant steps.

4. Three deeper and distinct furrows, parallel to the others, evidently tail-traces, from which small ripple-marks proceed like the vane of a feather.

An excellent photograph of the largest slab was exhibited; also outlines, several inches long, of the ten or twelve varieties of impressions of the natural size. By the aid derived from a recent paper in the Canadian Naturalist, by Dr. Dawson, "On the Footprints of *Limulus*, as compared with the *Prototichnites* of the Potsdam Sandstone," the suggestion was made that these impressions might have been the work of an analogous Crustacean.

Supposed Mistake as to the number of Phalanges in the thick-toed Animals that made the Footmarks in the Connecticut Valley.

The opinion seems to have been unanimous, with all who have examined the footmarks of the Connecticut Valley, that the number of phalanges denoted by the impressions in the thick-toed bipeds corresponds to those of most tridactyle birds, viz. (omitting the ungual phalanx, which would not show an impression distinct from that made by the penultimate phalanx) two in the inner toe, three in the middle, and four in the outer toe. And this is certainly the con-

clusion to which the best specimens would naturally lead. But recent examinations have led to the conviction that *one phalanx too many has been assigned to the outer toe*. If any one will look at the outline sketches of the fourteen species of thick-toed birds, as they are called, given in the Ichnology, — or, better still, if he will look at the specimens in the cabinet, from which these were copied, — he will see that the hindmost phalanx of the outer toe lies entirely farther back, or nearly so, than the first phalanx of either of the other toes, so far as the author had been able to ascertain since this subject had arrested his attention. This is not the case in living animals; but in birds especially, the first phalanx of the outer toe is abreast of that in the inner toe, though in the middle toe it is usually a little in advance of the others. Hence, what has been regarded as the imprint of the first phalanx of the outer toe was probably made by a heel-bone; and indeed in some cases this impression differs somewhat from the others. Hence the true number of phalanges in these fossil animals was three in the inner toe, and four in both the other toes. The author did not feel entirely satisfied that this conclusion would stand; but he had become more and more convinced of its truth, the more he examined the subject. Want of access to large collections of living animals and ill health had embarrassed his investigations.

Do the Protuberances on the under side of the toes correspond to the number of Phalanges, or to that of the articulations, or to neither?

These questions sprung up during this investigation, and have led to some examination. Plaster moulds of the feet of a few birds have been taken, which were exhibited, whose characters are as follows.

The protuberances on the foot of the turkey, both wild and domestic, correspond neither with the phalanges nor the articulations. They are more numerous than either, and very unequal as to size and depth. As many as six or seven can be counted. Those of the domestic hen are very similar.

In the *Botanus lentiginosus* they correspond to the articulations, — certainly so on the dried specimen from which the mould was taken.

The wings on the toes of the Coot expand along the phalanges, and contract at the joints. The expansions in the Crow's foot correspond to the articulations, as is learnt from some impressions on clay from the banks of Connecticut River.

A good mould of the feet of the South American Ostrich (*Rhea Americana*) shows rather indistinctly the normal number of phalanges in the middle toe, but gives no idea of the number in the other toes. This mould was taken by Professor Jeffries Wyman.

These results show the need of further investigations in this direction. They awaken a deeper interest in the remarkable uniformity of the phalangeal impressions of the fossil footmarks, apparently so much more perfect than in living animals.

Were any of the Animals that made the Fossil Footmarks Birds?

The facts above stated as to the number of phalanges, if admitted, of which some doubt may still remain, very much weaken the strongest argument for the ornithic character of the thick-toed bipeds; perhaps they are absolutely fatal to such an opinion; yet in all other respects the tracks correspond with those of birds. They were undoubtedly bipeds, and the long stride taken by some of them corresponds with that of wading birds, but of no other known animals. Whether anatomists would admit that the earliest birds might have been so unlike the present species as to a slight difference in the number of phalanges, must be left for them to decide.

Professor Hitchcock referred to the *Anomæpus* as furnishing another argument against the ornithic character,—especially to a remarkable specimen recently obtained for the Amherst Cabinet. It is eleven feet long, and of its forty-nine tracks, forty-five belong to *Anomæpus*, and sixteen of them are so perfect as to show the papillæ of the toes more or less. A drawing of the slab of the natural size was exhibited, showing the position and form, the phalanges and claws, and the papillæ of the whole. Four rows of the tracks were manifest, the longest containing seventeen tracks, and three of these rows would be pronounced by a good judge of tracks to be those of thick-toed birds; especially as the phalangeal impressions,—certainly on the inner and middle toes, and probably also on the outer one,—correspond with those of birds; that is, as we have been accustomed to regard them. For here, too, the first phalanx of the outer toe is thrown back beyond that of the other toes. On looking, however, at the fourth row, which for the first five steps exactly resembles the others, we find at the fifth step two tracks nearly abreast, with long stout heels running back several inches, and a little in advance two small five-toed impressions; proving beyond all question that the animal

was a quadruped with unequal feet and long heels to its hind feet ; as is still further proved by the trace of a tail. The animal seems to have rested for a moment upon all its feet ; and then it rose and went forward again upon the toes of its hind feet ; in other words, it was *digitigrade* ; and Professor Hitchcock suggested that several of these ancient animals must have used only the toes of their hind feet in walking, and rarely brought their fore feet to the ground.

We must not hastily conclude from these facts that all the tracks of apparently biped animals in the valley are really those of quadrupeds, which proposition Professor Hitchcock attempted to prove in a paper read before the American Association for the Advancement of Science, at their Newport meeting, and published in their Proceedings. Moreover, he had attempted to show in his Ichnology, that the facts as to the number of phalanges in the *Anomæpus* might be explained without destroying the evidence of an ornithic origin in the fourteen thick-toed bipeds : for other slabs in the cabinet had taught the same facts, though less distinctly than the specimen above described. The facts, however, do show us that the quadrupeds of sandstone days had strong ornithic characters, and they justify the conclusion, that, if none of the animals that made the tracks were veritable birds, they approached very near them in character. Every department of palæontology teaches that many of the ancient animals possessed intermediate characters between the less perfect races that preceded and the more perfect ones that followed, so that we should not think it strange if Ichnology teaches the same, as it does most decidedly ; and it may be that, so nearly balanced sometimes are the characters between birds and reptiles, that from tracks alone we may never be able certainly to determine to which class the animals belonged.

The recent discovery in the lithographic quarries at Solenhofen, in Bavaria, of the *Gryphosaurus*, is a striking illustration of this subject. For, according to the discoverer, it was a *feathered fossil reptile*, feathered on the fore legs, and with a radiate fan at the extremity of the tail. Its osteology, also, in some important respects, corresponds to that of birds. Indeed, it was stated by a member of the Academy, that Professor Owen still maintains that this animal was a bird, in opposition to the German anatomists, Wagner and Meyer. But if such eminent authorities differ, when even the skeleton is before them, much more may we hesitate when we have only tracks.

It may be, however, that light may come from Ichnology, which

even the fossil skeleton would not teach. Hence the importance of large collections of the footmarks. Professor Hitchcock stated that he had counted the individual tracks in the Amherst Cabinet, and found them to exceed 12,000, nearly 4,000 of which are the tracks of insects. Within a few days, through the liberal donations of a few friends of science, the entire collection of Roswell Field, made at Turner's Falls, has been added, which will increase the collection by several thousand tracks. May they furnish new light to future explorers!

[POSTSCRIPT, *January 15, 1863.* Among the specimens just added to the cabinet, as mentioned above, are some very perfect ones, showing the phalangeal impressions with great distinctness. And one of them, probably a new species of *Anomæpus*, has in the outer toe, besides the hindmost impression, which I now regard as made by a heel-bone, *four other perfectly distinct impressions in at least two tracks.* Here, then, we have the normal number for birds, after setting aside the hindmost. Again, on another quite perfect specimen of a *Grallator*, I find the same facts, — not so distinctly marked, indeed, as in the first case, still obvious enough to a practised eye; and now that attention has been directed to this point, I am anxious to re-examine all my specimens of the fourteen thick-toed bipeds, to see whether they may not all have had the same number of protuberances. I incline to the opinion that it may so turn out; and if so, that we may still confidently maintain that these species were birds. — *March 20.* It so turns out.]

Dr. B. A. Gould directed the attention of the Academy to an echo, of remarkable excellence, in the chimney of the Roxbury Chemical Works.

The buildings have been recently taken down, with the exception of this tall chimney, which must be nearly two hundred feet high, and into which entrance is easy by means of large, door-like flues. Sounds made within the structure are repeated with great distinctness many times, — and repeated trials showed the possibility of obtaining at least ten clearly audible repetitions, for sounds of moderate strength and low pitch, such as that made by stamping with the foot upon the frozen ground. The nearest estimate which Mr. Gould could make with the aid of a common watch, gave 3^s.4 or 3^s.5 as the interval between the primitive sound and the tenth echo, — corresponding to a series of reflections from the open end of a pipe about one hundred and ninety feet high, at the temperature of freezing.

The interval before the first echo was sufficient to permit the full utterance of some five-syllabled words, such as "quadrupedante," "anemometer," etc., — which would indicate as much as thirty-five hundredths of a second, at the least possible estimate.

He had not succeeded in learning the actual height of the chimney, but had taken measures to do so, as he hoped by means of a careful determination of the fundamental tone to succeed in setting the whole column of air in vibration.

Articulate sounds of all kinds appeared to be reproduced by the echo without any loss of their original distinctness, except the sibilants. Mr. Gould had found all the other consonants, and many of their combinations, such as *pl, cl, tr, gn, kn, lt*, as also the aspirate, to be echoed with as perfect enunciation as the original sound. But a hiss, or the letter *s*, was repeated as a very sharp aspiration. The echo of *z* was a softened aspiration, and even *f* and *th* could not be obtained with distinctness. These (including of course *x*) were the only exceptions to completeness of articulation in the echoes. A prolonged musical note filled the cavity with resonance until it was almost unendurable, and it was easy by sounding three harmonic notes, such as C, E, and G, to obtain the effect of a chord in full perfection.

Mr. Safford made the following communication:—

In the sixth volume of his *Astronomical Journal*, Dr. B. A. Gould has given a detailed investigation of the places of 48 stars within 25° of the North Pole; and has since published the results of a more complete investigation of the places of 40 of these same stars, together with those of 132 stars nearer the equator. The prefatory letters of the pamphlet in which these latter results are contained (without any details of the investigation), bear the dates Sept. 10th, 1862, and Sept. 13th, 1862; though the work seems not to have been published till some months later.

At the meeting of the Academy on Sept. 9th, I presented the results of a somewhat similar investigation upon the positions of 25 stars within 10° of the North Pole; of which 4 were common to my own catalogue and that of Dr. Gould; and also upon the positions of an extensive list of time stars, of which 49 were common to the two. My Memoir (now in the hands of the Publishing Committee of the Academy) contained also the positions of 47 stars extracted from the materials of Wolfers's *Tabulæ Reductionum*.

The four polar stars differ thus in the two catalogues (G. denoting Dr. Gould's results, S. my own, in both cases reduced to the ecliptic of 1855) for the time 1855 $+ t$.

	G. — S.		$\Delta \delta$	
	$\Delta \alpha$		$\Delta \delta$	
51 Cephei H.	—0.66	—0.0752 t	—0.40	+0.026 t
1 Draconis H.	—0.13	—0.0127 t	+0.10	+0.005 t
ϵ Ursæ Minoris	—0.09	+0.0039 t	+0.06	
λ Ursæ Minoris B.	—0.14	+0.0023 t	—0.11	

Much the largest discrepancy occurs in the case of 51 Cephei H.; for which Dr. Gould has omitted the best early authority, — Struve, of 1815, — and employed unreliable catalogues (Lalande, Piazzzi, Groombridge, for A.R.), with uncertain corrections for the proper motions. His formula differs, therefore, from observation, by more than 2^s in 1815, and by varying amounts, but with the same sign, from every published year's work (but one) of an observatory, since 1854, the date of the last observations employed. The single exception is the Washington Observations of 1861, where the erroneous place of this same star was used (by a peculiar process)* in determining itself over again. The time stars of the two lists agree better; the following table gives the differences for 1855. Stars which in my memoir are quoted from the excellent catalogue of Wolfers have numbers corresponding to them in the *second* column; the results of comparison of my own catalogue are contained in the *third* column; the first being occupied by the star's name. The initials W., G., S., denote the right ascensions of the three catalogues for 1855.

The mean of the 30 Nos. W. — G. is $+0^{\circ}.033$; mean diff. from this mean $\pm 0^{\circ}.0205$.

“ “ 49 “ S. — G. $+0^{\circ}.026$; “ “ “ $\pm 0^{\circ}.0213$.

The largest discrepancy is in the case of β Corvi. There is some

* These Washington observations of 51 Cephei are almost exclusively such that the instrumental corrections depend on this star and δ Ursæ Minoris. Let e be the error of the assumed A.R. of 51 Cephei, and e' that of δ Ursæ. The error hence resulting of the deviation (n) of the transit instrument at the pole will be $\frac{e - e'}{\tan \delta + \tan \delta'}$; or, for these stars, $\frac{e - e'}{20.8 + 16.9} = \frac{e - e'}{37.7}$; and the resulting error of the position of 51 Cephei will be $20.8 \frac{e - e'}{37.7} = 0.55 e - 0.55 e'$; that is, the so-called observed position (even deduced from 100 or 1,000 observations) will be erroneous by *more than one half* the algebraic difference of the errors of the two catalogue positions. The process is one not approved by European astronomers.

doubt about Bradley's *two* observations of this star; one or both of them are 1^s wrong.

	W.—G.	S.—G.		W.—G.	S.—G.
α Andromedæ	+0.010		β Corvi		+0.095
γ Pegasi	+0.067		12 Canum Ven.		+0.028
β Ceti		+0.038	δ Virginis		—0.006
ϵ Piscium		—0.022	α Virginis	+0.007	
δ Ceti		+0.017	ζ Virginis		+0.018
η Piscium		+0.061	η Boötis		+0.025
β Arietis		+0.043	α Boötis	+0.019	
α Arietis	+0.040		ϵ Boötis		+0.027
γ Ceti		+0.018	α^2 Libræ	+0.013	
α Ceti	+0.011		β Libræ		+0.021
η Tauri		+0.030	α Coronæ	+0.048	
γ Eridani		—0.008	α Serpentis	+0.044	
ϵ Tauri		+0.052	δ Ophiuchi		+0.027
α Tauri	+0.019		α Scorpii	—0.001	
ι Aurigæ		+0.026	κ Ophiuchi		+0.043
α Aurigæ	+0.041		α Herculis	+0.063	
β Orionis	+0.044		α Ophiuchi	+0.041	
β Tauri	+0.027		μ Herculis		+0.039
δ Orionis		+0.030	μ^1 Sagittarii		+0.012
α Leporis		+0.005	α Lyræ	+0.041	
ϵ Orionis		+0.024	β Lyræ		+0.044
α Orionis	+0.039		ζ Aquilæ		+0.044
μ Geminorum		+0.055	δ Aquilæ		+0.043
γ Geminorum		+0.046	γ Aquilæ	+0.051	
ϵ Canis Majoris		+0.010	α Aquilæ	+0.071	
δ Geminorum		+0.011	β Aquilæ	+0.060	
β Geminorum	+0.016		α^2 Capricorni	+0.054	
ι Navis		+0.008	α Cygni	+0.020	
ϵ Hydræ		+0.001	ζ Cygni		+0.046
α Hydræ	+0.015		β Aquarii		+0.025
ϵ Leonis		+0.021	ϵ Pegasi		+0.012
α Leonis	—0.007		α Aquarii	+0.050	
γ Leonis, pr.		+0.049	δ Aquarii		0.000
ρ Leonis		+0.008	η Aquarii		+0.010
ι Leonis		+0.080	ζ Pegasi		+0.030
δ Leonis		+0.029	α Piscis Aust.	+0.015	
δ Crateris		+0.027	α Pegasi	+0.049	
ϵ Leonis		+0.002	ι Piscium		+0.006
β Leonis	+0.019		ω Piscium		+0.012
η Virginis		+0.015			

Five hundred and sixteenth Meeting.

January 13, 1863. — MONTHLY MEETING.

THE PRESIDENT in the chair.

The Corresponding Secretary read a letter from Dr. C. M. Warren, in acknowledgment of his election as a Fellow. Also various letters relative to the exchanges of the Academy.

A bronze medal struck in memory of the late Frederick Thiersch, presented by the Royal Bavarian Academy, was received and exhibited.

Professor H. J. Clark made a detailed communication upon the group of Medusæ of which *Lucinaria* is the type,—a group which he finds now to consist of two families and seven if not eight genera, the characters and structure of which were illustrated.

Dr. Dexter made a communication upon Revolving Storms, in particular upon one of June last, which he had observed and investigated.

Mr. Safford remarked upon certain forms of personal equations.

Professor B. Peirce commented upon certain remarks upon the American Lunar Tables contained in a recent volume of the Transactions of the Royal Astronomical Society.

Five hundred and seventeenth meeting.

January 28, 1863.—STATUTE MEETING.

THE PRESIDENT in the chair.

The Corresponding Secretary read letters relative to the exchanges of the Academy.

An artist's proof of Mr. Marshall's engraving of Stuart's portrait of Washington, presented by the engraver, was exhibited, and ordered to be appropriately framed.

On motion of Mr. Folsom, the thanks of the Academy were voted to Mr. Wm. E. Marshall for this valuable donation.

Capt. Henry L. Abbot, U. S. Topographical Engineers, was elected a Fellow, in Class I., Section 4.

Wm. W. Story, Esq., was elected a Fellow in Class III., Section 4.

General A. A. Humphreys, U. S. A., was elected an Associate Fellow, in Class I., Section 4.

Christopher Hansteen, of Christiania, Norway, was elected a Foreign Honorary Member, to fill the vacancy left in Class I., Section 3, by the death of Biot.

Leopold von Ranke, of Berlin, was elected a Foreign Honorary Member in place of the late Sir Francis Palgrave, of Class III., Section 3.

Mr. Alvan Clark read a paper entitled "The Sun a small Star."

Professor B. Peirce made a communication on the vibration of solids floating in water, in reference to the displacement and stability of vessels in a heavy sea.

The following paper was presented

On the Aluminates of Baryta, by W. P. DEXTER.

M. H. Sainte-Claire Deville has described, in the *Comptes Rendus* for February, 1862, a "very curious compound," an aluminate of baryta, soluble in about ten parts of water, and which can be made to crystallize out of alcohol. The composition assigned to the crystals is one atom of alumina, one of baryta, and four of water. The analysis, however, leaves it uncertain whether they contain four or three atoms of water.

The existence of a compound of alumina and baryta has been long known to chemists. The solubility of alumina in solution of baryta is mentioned by Berzelius,* who states that alumina acts as an acid in relation to the alkalies, the alkaline earths, and some of the stronger metallic bases. And Vauquelin† speaks of two compounds, the one soluble, containing more baryta, the other insoluble, and containing excess of alumina.

According to Unverdorben,‡ a neutral aluminate can be obtained by dissolving alumina in caustic potash, evaporating to dryness, and taking up the excess of potash with alcohol. Its solution gave, with chloride of barium, a gelatinous precipitate, containing equal equivalents of alumina and baryta, and the aluminates of other bases could be precipitated in the same way. The solution of alumina in excess of potash gave, with the chlorides of barium and calcium, precipitates resembling the former, but containing two equivalents of baryta to one of alumina; they were dialuminates.

The analyses of these compounds given by Unverdorben agree so

* *Traité de Chimie*, Tom. II. p. 155 (Paris, 1846).

† L. Gmelin, Bd. II. s. 296.

‡ *Pogg. Ann.*, Bd. VII.

precisely with the equivalent numbers at that time in use, that I cannot but think, considering the difficulty of obtaining in a pure state precipitates of a gelatinous consistency and decomposable by the carbonic acid of the air, that he has given the calculated numbers, and not the results of his analyses.

This subject was studied by me several years ago; the results of that investigation I have now the honor of laying before the Academy.

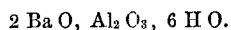
On repeating Unverdorben's experiment, I found that neutral aluminate of potash gives, as he states, a precipitate with chloride of barium; much alumina, however, remained in solution, and on attempting to wash the aluminate of baryta, the greater part of it dissolved and passed through the filter.

When freshly precipitated alumina is dissolved in hot concentrated solution of baryta, a compound of these bodies separates in minute crystals, which attach themselves to the sides of the vessel. If the solution is dilute, it must be concentrated; the crystals then form suddenly during the evaporation, and adhere so strongly to the glass that it is difficult to remove them by mechanical means. They are transparent, colorless, are hard and heavy, and, while covered by the liquid, have an almost adamantine lustre. They are decomposed by the carbonic acid of the air, and by water, which separates from them alumina. For these reasons, and from their adhesion to the glass, it is somewhat difficult to collect them for analysis.

1.0605 gr. of these crystals gave 0.972 sulphate of baryta and 0.2197 alumina; whence we have for their composition,

	Found.	Equivalents.	Calculated. 6 H O.	5 H O.
Ba O	60.18	1.96	59.25	61.39
Al ₂ O ₃	20.62	1.00	19.86	20.58
HO	19.20	5.32	20.89	18.03
	<u>100</u>		<u>100</u>	<u>100</u>

It is doubtful whether the salt contains 6 or 5 atoms of water; perhaps the more probable formula is



In a preparation in which the baryta had been boiled with a considerable excess of alumina, the liquid separated from the crystals was evaporated *in vacuo* over sulphuric acid to dryness. There remained an amorphous, friable, white mass, containing, exclusive of water,

Ba O	69.46
Al ₂ O ₃	30.54

These numbers are not in atomic proportion ; and the mass was a mixture of aluminate and dialuminate.

In a similar liquid, but of another preparation, alcohol produced an amorphous precipitate of nearly the same composition.

The analysis gave

Ba O	65.70
Al ₂ O ₃	<u>34.30</u>
	100

being intermediate between the neutral aluminate, which requires 59.86, and the dialuminate, in which is 75 per cent of baryta.

It is easy to obtain, by a different process, a solution containing alumina and baryta in nearly the proportion of equal atoms, but many attempts which I made to separate the salt proved unsuccessful ; only once was I able to get a body having this composition, and on repeating that process it gave me a different result.

A mixture of carbonate of baryta and chloride of sodium fuses at a very moderate temperature and without decomposition. If alumina be added to the melted mass, or to the mixture before ignition, a brisk disengagement of carbonic acid ensues. Water dissolves from the mass, beside the chloride of sodium, a considerable quantity of neutral aluminate of baryta, or more probably, as will presently appear, a double salt of aluminate of baryta and chloride of sodium. The solution is unaffected by caustic alkalies ; acids and chloride of ammonium precipitate the alumina, the latter with disengagement of ammonia. Equal equivalents of alumina and carbonate having been thus fused, and the mass digested with water, the solution gave on analysis,

Ba O	63.51
Al ₂ O ₃	<u>36.49</u>
	100

or from five to six per cent more baryta than is required by the composition of the neutral aluminate.

Thinking that the excess of baryta would be precipitated by carbonic acid before the baryta contained in the neutral aluminate was acted upon, a similar solution was exposed, with frequent agitation, to the air, or a stream of carbonic acid was led through it until with the carbonate of baryta a sensible quantity of alumina was precipitated. The liquid then contained

Ba O	62
Al ₂ O ₃	<u>38</u>
	100

being nearly 3½ per cent of baryta in excess.

With the same view, to another solution a very dilute hydrochloric acid of known strength was added until a precipitate of alumina became visible. But the quantity of acid which could be so added corresponded to only the half of one per cent of baryta; deducting this amount, the liquid contained

Ba O	61.44
Al ₂ O ₃	38.56
	100

A solution giving the same reactions may be obtained by fusing carbonate of baryta and alumina with other chlorides, or with salts of a similar chemical nature. By employing a salt easily soluble in alcohol, I hoped to be able to separate the aluminate. To this end 5 parts of carbonate of baryta and 2 of alumina were fused with 10 parts of bromide of sodium, the mass dissolved in water, and evaporated in a water-bath under a pressure less than that of the atmosphere, and finally *in vacuo* over sulphuric acid. The residue was digested with alcohol, brought upon a filter and washed with alcohol till the washings contained only a trace of bromine. The mass was then only partially soluble in water, the solution gave the reactions of aluminate of baryta, but contained a great deal of bromine. In fact, under these circumstances a double salt of aluminate and bromide is formed which is insoluble in alcohol. If the simple aluminate be really soluble in alcohol, as would be inferred from the statement of M. Deville, it is not easy to understand how its combination with bromide of sodium should be nearly insoluble in that liquid.

Finally, carbonate of baryta was fused with fluor-spar and alumina. The fusion is easily effected, the fluor-spar is apparently not decomposed, and the aluminate is formed as in the former cases. The fused mass was very finely pulverized and digested with water, which could here dissolve nothing but the aluminate. The solution contained

Ba O	70.5
Al ₂ O ₃	29.5
	100

which is not very far from the composition of the dialuminate already described.

Another solution made in the same way was evaporated until the salt began to separate, and then precipitated with twice its volume of alcohol and the precipitate washed with alcohol: it was found to be composed of

Ba O	62.84
Al ₂ O ₃	37.16
	100

When this precipitate was treated with water, it dissolved only partially, leaving a considerable residue of alumina. This seems to show that the neutral aluminate is not soluble without decomposition in water, and to explain why in its solutions the baryta was invariably found in excess.

Beside the reactions which have been already mentioned as characterizing the aluminates, the solution of the precipitate by alcohol (which was found to contain 64 per cent of baryta and 36 of alumina) gave with nitrate of silver a voluminous, flocculent, chocolate-colored precipitate, subsiding quickly in the liquid, and soluble in ammonia with very little residue. The ammoniacal solution acidified with nitric acid, and then saturated with ammonia, let fall a large quantity of alumina.

With acetate of copper it gave a precipitate of a delicate blue color, in other respects resembling alumina: it was completely soluble in ammonia, and from the ammoniacal solution the alumina was precipitated by chloride of ammonium.

A concentrated solution of chloride of calcium produced at once a white flocculent precipitate, very easily and completely soluble in dilute nitric acid: in a dilute solution of the same salt no precipitate was formed.

The analysis was in every case effected by first separating the baryta as sulphate, then neutralizing with ammonia and completing the precipitation of the alumina with sulphide of ammonium. The alumina was removed with a spatula from the filter after being incompletely washed, redissolved in hydrochloric acid, the filter washed with this acid and the alumina again precipitated and collected upon the same filter.

While endeavoring to obtain the neutral aluminate of baryta, I observed two double salts of the aluminate with chloride of barium, and others doubtless may be formed in the same way. When chloride of aluminium, which for this purpose is most easily formed by precipitating sulphate of alumina with chloride of barium, is added to a hot solution of baryta, chloride of barium is of course formed, and the separated alumina redissolves in the excess of baryta. By further addition of the chloride a permanent precipitate appears, which consists of alumina combined with a small quantity of baryta. The filtered liquid

deposits on evaporation crystals, *apparently* rhombic tables and prisms, which are not so hard and do not attach themselves so firmly to the glass as the crystals of the dialuminate. They contain chlorine, and are soluble in hot water, giving a slightly turbid solution: cold water dissolves them less easily, but does not extract the chlorine, which is found in the washings until they are completely dissolved. In *concentrated* solution of baryta they were only partially soluble; what remained, after being dried by pressure in paper, was free from chlorine and composed of

Ba O	62.11
Al ₂ O ₃	37.89
	100

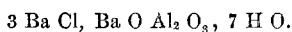
being very nearly the composition of the aluminate previously obtained, and probably as a double salt, by fusing alumina and carbonate of baryta with chloride of sodium, — a neutral aluminate of baryta with slight excess of base. In the moist state it was little soluble in very concentrated solution of baryta, but dissolved at once on dilution with water.

On repeating the experiment I failed to obtain this body; owing perhaps to insufficient concentration of the baryta, the crystals dissolved in it without residue.

The crystals of the double salt, dried between folds of paper, lost *in vacuo* over sulphuric acid 0.23 per cent, evidently adhering moisture. 0.7137 gr. then gave 0.6078 Ag Cl, 0.6692 Ba O, S O₃, and 0.0692 Al₂ O₃; from which their composition appears to have been

		Equivalents.
Ba Cl	61.76	3.00
Ba O	16.15	1.07
Al ₂ O ₃	9.69	0.95
H O	(12.40)	6.97
	100	

and is represented by the formula



The aluminate contained in the double salt consisted of

Ba O	62.50
Al ₂ O ₃	37.50
	100

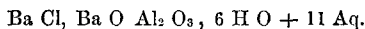
The aluminate thus appears to have had in combination with chloride of barium almost exactly the same composition, the same excess of

base, which was found in it when uncombined, by the former analyses.

The liquid which had been decanted from the crystals just described, let fall, after standing well covered for some hours, a snow-white crystalline powder in considerable quantity. This powder, which seemed to be free from crystals of hydrate of baryta, when compressed between paper became of a plastic or cheesy consistency. It was not washed. The analysis gave the following results: 0.566 gr. weighed, after remaining *in vacuo* over sulphuric acid till the weight became constant, 0.4232; of this, 0.423 gave 0.2076 Ag Cl, 0.3476 Ba O S O₃, and 0.073 Al₂ O₃, whence we have the composition,

		Equivalents.
Ba Cl	26.58	1.00
Ba O	20.79	1.06
Al ₂ O ₃	12.90	0.98
H O	(14.51)	6.31
Aq	25.22	10.98
	100	

Aq designating the water lost *in vacuo*. The formula of the salt is then



From the difficulty of freeing a body of such consistency from all adhering liquid, and its tendency to absorb carbonic acid during the requisite manipulations, it is very probable that the water may not be correctly given by the above figures.

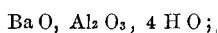
The aluminate of baryta in the double salt has the composition

Ba O	61.71
Al O ₃	38.29
	100

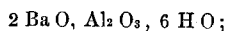
which differs little from that previously found for the neutral aluminate.

We know then, in the crystalline state, the following compounds of alumina and baryta:—

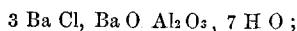
A neutral aluminate described by M. Deville,



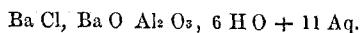
a dialuminate of the formula



a double salt of aluminate of baryta and chloride of barium,



and a second double salt, containing the same simple salts, and composed of



Five hundred and eighteenth Meeting.

February 10, 1863. — MONTHLY MEETING.

The PRESIDENT in the chair.

Mr. Ritchie exhibited and explained his newly-invented compass, designed to obviate the effect of local attraction.

Professor Hitchcock read the following postscript to his paper communicated at a former meeting.

Since I presented my paper on Footmarks, in December, I have continued my researches with a large addition of new specimens, and I feel a strong confidence that the following positions may be relied upon.

1. The protuberances on the under side of the feet of living animals do not, as a general fact, correspond either to the number of phalanges or of articulations.

2. In some species, however, there is such a correspondence, sometimes showing the number of articulations, and sometimes that of the phalanges.

3. The hindmost impression in the outer toe of the thick-toed biped animals, described in my Ichnology as birds, was made, not by a phalanx or a joint, but by a heel-bone or a process on the tarso-metatarsal bone.

4. Besides this hindmost impression, however, a more careful examination of specimens has satisfied me that the outer toe had four phalanges besides the ungual, the middle toe three, and the inner one two, corresponding to the number in tridactyle living birds.

5. Still more certain is it that the quadruped *Anomæpus*, described in the Ichnology, had the same number.

6. The same is true, without much doubt, in the remarkable feathered animal, the *Archæopteryx*, lately discovered at Solenhofen.

7. Hence we cannot distinguish in fossils, as has always been supposed, between birds and quadrupeds, by the number of phalanges in their feet.

8. Hence there is as much reason to suppose that some of the fossil footmarks were made by birds, as there is for putting *Archæopteryx* into that class, as has been done by eminent zoölogists. These old animals, both the fossil and the *Lithichnozoa*, must have differed a good deal in their anatomical structure from birds, lizards, and marsupials ;

and they seem to have been so nearly intermediate between the different classes that it may be impossible to fix their place with certainty, either from tracks or skeletons. It is interesting to find that these two sources of evidence illustrate and corroborate each other.

9. The question whether the hindmost impression on the outer toe in the fossil footmarks was made by a tarsal bone, or some process on the tarso-metatarsal, has only just engaged my attention. It may have a most important bearing on the whole subject. But I am not yet prepared to present any conclusions.

Dr. B. A. Gould made a communication on the diurnal change in the position of the azimuthal arms of the transit-instrument along the Atlantic coast of the United States.

Professor Hitchcock, in this connection, recounted several observations showing a singular pressure on the earth's surface from the east, as exhibited in the pushing up of the strata in a quarry at Portland, Connecticut, and at Rutland, Vermont. And he suggested that this might account for certain peculiar rumbling sounds in the earth heard at times in Connecticut.

Professor Parsons discoursed upon the resemblances between the German and English Jury and the analogous institutions of Greece and Rome.

Five hundred and nineteenth Meeting.

March 10, 1863. — MONTHLY MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read a letter from General A. A. Humphreys, dated Camp near Falmouth, Virginia, in acknowledgment of the announcement of his election as an Associate Fellow.

Also, from Captain Henry L. Abbot, U. S. Engineers, in acknowledgment of his election as a Fellow of the Academy.

Dr. Charles Pickering propounded the inquiry whether the irregularity in the eclipses of Jupiter's satellites may not be due to the difference between real and apparent time. To which Professor Peirce returned a negative response.

Dr. Beck and Professor Washburn commented upon the Jury system, as to its origin, character, and relations to the analogous institutions in ancient Greece and Rome.

Mr. Folsom pointed out the origin and history of the line,

“Flos rubet, inque auras frustra disperdit odorem,”

which Gray had been thought by some to have plagiarized.

Five hundred and twentieth Meeting.

April 14, 1863. — MONTHLY MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read various letters relative to the exchanges of the Academy.

Also a letter from Professor Christopher Hansteen of Christiania, Norway, in acknowledgment of his election as a Foreign Honorary Member.

Mr. Alexander Agassiz read a paper, of which the following is a summary : —

On the Embryology of Asteracanthion berylinus Ag. and a species allied to A. rubens M. T. Asteracanthion pallidus Ag. ; by A. AGASSIZ.

The following account of the development of our common star-fishes is intended to appear in full, with many plates, in the fifth volume of the Contributions to the Natural History of the United States of Prof. Agassiz. A part of the material for the investigation was obtained by artificial fecundation, and the rest by fishing for it with the dip-net during the greater part of the summer of 1862.

The larvæ of our common star-fishes are found floating in large numbers at night among those long trains of cast-off skins of barnacles collected by the tide, which appear to provide them, as well as many of our small crustacea, hydroids, and annellids, with food during the time when they swim freely about. They seem to be nocturnal, as I have only found here and there a single specimen when fishing for them in the daytime under exactly the same circumstances of tide and wind.

The adult larvæ move about quite rapidly by means of the cilia of their vibratile chord. Their position in the water is much more con-

stant than when young. The anal portion is kept in advance when moving, and the larva rotates about, but not as frequently as when young; moving more generally with either the ventral or dorsal side uppermost, and more rarely in such a way that the profile can be seen. When at rest, they invariably assume one and the same position; that is, turn slightly obliquely below the anal portion, with the dorsal surface downwards. In this way they often remain for a long period, simply carried about by the currents; the only movements being the expansion and contraction of the œsophagus, and the slow bending and twisting of the arms in every direction.

Up to the stage represented in Fig. 9, all the larvæ were raised by artificial fecundation from eggs of *Asteracanthion berylinus* Ag. At the time when I discovered these larvæ I immediately examined the ovaries of our star-fishes, and found that in one species, the *beryllinus*, the eggs were not yet sufficiently advanced to be fecundated, while the eggs of the second species, which is so common on our rocks, the *Ast. pallidus*, had all escaped. I had, however, been fortunate enough to find quite young larvæ of this second species in which the water-tubes were still exceedingly small, and had made a complete series of drawings of general outlines from their youngest stage up to the time when the star-fish is formed, so that I am certain that all the young I have represented as belonging together are those of one species, as the interval between the time when these two species spawn is more than three weeks.

The time of spawning is very short; three or four days after the *Ast. berylinus* began to spawn it was quite difficult to find females which had not lost their eggs, and a week after that period I found none. Owing to this great difference in the time of spawning, and its short duration, the dates at which I caught these star-fish larvæ floating about leave no doubt to which of the species the larvæ belonged. A careful comparison of the youngest specimens also shows very striking differences, which will always enable an observer to distinguish readily the larvæ of these two species, even in their earlier stages.

The males can easily be distinguished from the females by their difference of color; the females being always slightly bluish, while the males have a decidedly reddish tint. The same difference in color is noticed in our Sea-urchin, *Toxopneustes drobachiensis*. The females are of a light green at the time of spawning, while the males are of a dull vermillion color.

In eggs which have been fecundated artificially (Fig. 1), the spermatic particles surround like a halo the whole of the outer envelope, beating about its surface with the greatest violence. The yolk soon begins to contract after the germinative vesicle and dot have disappeared, and then divides into two spheres. (Fig. 2.)

The segmentation takes place very rapidly, and as soon as there are eight spheres (Fig. 3), they arrange themselves in such a manner as to enclose the remaining space, which is more and more separated as the spheres become more numerous; finally, there is a complete envelope formed before the young makes its escape from the egg.

The young when it escapes is spherical. The walls of the envelope are of the same thickness. One side becomes thicker (Fig. 4); the embryo flattens on the thick side. This wall is then bent in so as to form a slight cavity, in which fluid circulates. (Fig. 5.) This cavity extends half the length of the larva (Fig. 6), then swells at the extremities. The walls become thinner; the pouch formed at the end of the cavity develops laterally to form two smaller pouches (Fig. 7), which soon become small hollow bodies entirely separated from the main cavity. (See Fig. 10.) The main cavity bends slightly to one side (Fig. 8), and eventually forms a junction with a depression opposite to it, and there the mouth is formed. The other opening, which was the first to be developed, thus becomes the anus.

This bent tube divides into three distinct regions, forming the œsophagus, the digestive cavity, and the alimentary canal. (Fig. 9.)

The small hollow bodies, the water-tubes, which are not connected with one another in the young embryos (Fig. 10), differ one from the other. One, the left (when seen from above), connects with the surrounding medium by means of an opening, the water-pore. (Fig. 9.) In older specimens these two tubes extend to the extremity of the digestive cavity, and towards one another, beyond the mouth, where they unite, forming a Y-shaped tube. (Fig. 11.) Arms are developed which are edged with rows of vibratile cilia. Some of these arms are of a different character, having different appendages (see Figs. 12, 13). On these water-tubes is developed the star-fish; one of the water-tubes (the one with the water-pore) developing the actinal side and the tentacles (Fig. 13), the other developing the spines and the abactinal area (Fig. 12). These opposite parts of the star-fish are open (Fig. 13) pentagonal spiral surfaces, not in the same plane, but making nearly a right-angle with one another. The water-pore becomes the madreporic body.

The open pentagons do not close till after the star-fish has absorbed the whole of the larva. The complicated system of arms and the whole of the Brachiolaria is absorbed by the star-fish, which is not separated from the larval stock, as seems to be the case in Bipinnaria according to Müller's statements.

The arms of the star-fish are broad and short in the young. (See Figs. 14, 15, 16.) The suckers are pointed, and arranged only in two rows (Fig. 17). The disc is developed only later. The odd terminal tentacle has an eye at its base, and never develops a disc (Fig. 17). The abactinal surface is very arched (Fig. 18). The spines are arranged in regular rows, and the plates remind us of the arrangement of plates of Crinoids (Fig. 16). The anus opens near the edge of the disc on the lower side. The madreporic body also is situated on the edge (Fig. 17).

The mode of development of star-fishes, as observed in our *Astera-canthion*, cannot be called a case of alternate generation, nor is it a metamorphosis in the ordinarily received sense. It is, in fact, a mode of development peculiar to Echinoderms, something entirely different from what we find in any other class of Radiates. It is not an alternate generation; for the Brachiolaria can in no way be called a nurse, as each Brachiolaria produces but one star-fish, the whole Brachiolaria being absorbed by the star-fish, and not a single appendage left out. Nor is it a metamorphosis, as the changes which take place are so gradual, that at no time can the line of demarcation be drawn between two stages, with any degree of precision, as in Crustacea or Insects. It is a mode of development eminently Echinodermoid, and whether we observe it in the Ophiurans, the Sea-urchins, the Holothurians, or the Crinoids, there seems no doubt, from the observations of Müller, that it takes place according to one and the same plan.

Lately there has been a great deal of discussion among the writers on Echinoderms, as to whether the madreporic body was a proper point to start from to draw the axes of the body; Agassiz, on one side, maintaining that the madreporic body was constantly in the same relation to the different parts of the Echinoderm; while Müller, Desor, and Cotteau have been the most prominent opponents of this view. The mode of formation of the madreporic body seems to me to decide this question. It is invariably on the left water-tube that we find the madreporic body. While the star-fish is developing, it is placed at the angle of the upper arm, and the natural consequence is, that the madreporic body will invariably be found opposite the middle arm of the

five, when the pentagon has become closed. The opening of the anus, on the contrary, has no such clear and precise position with reference to the odd arm as the madreporic body. At any rate, it is perfectly apparent that the madreporic body is always in the suture of the terminal arms of the pentagon, which places it opposite the odd arm. The case of the *Echinometradæ* and of *Salenidæ* is constantly brought up to show that the madreporic body is not connected with any definite axis of the body; but from what has been shown of the twisted state of a young star-fish, and of the manner in which it unwinds itself afterwards, and from the fact that in *Echinidæ* we find families in which the unwinding is not completed, and the madreporic body naturally cannot be in a line passing through the middle of the animal, though still opposite the odd arm whatever its position may be, owing to this embryonic feature, as in the *Echinometradæ*, we infer that the madreporic body retains the same normal position in all Echinoderms.

On embryological grounds, from the changes which the young star-fishes undergo, it is evident that all the star-fishes with pentagonal outline and pointed tentacles, like *Ctenodiscus*, stand lower than star-fishes like *Luidia*, with elongated arms and pointed tentacles; that pentagonal star-fishes, like *Culcita*, without any spines or plates, though higher than those just mentioned on account of the discs of the tentacles, stand lower than those pentagonal star-fishes like *Hippasteria* and *Antennea*, where we have a complicated system of plates. Next, those star-fishes which have suckers and long, smooth arms, like *Ophiaster*, stand lower than those star-fishes which have tentacles provided with suckers, and complicated spines on the surface of their long, slender arms, as *Asteracanthion*. Finally, as a general rule, all star-fishes with two rows of suckers are lower than those which have four, the former being an embryonic character. Among other characters which are not those of the order, but nevertheless exist in the young star-fish, the most prominent is the position of the madreporic body on the actinal side, which is a feature of the Ophiurans. The position of the anus next to the mouth is eminently crinoidal, as well as the arrangement of the plates on the abactinal side; while the arched abactinal area and the tall spines remind us of the Echinoids.

The mode of development of *Echinaster* is not according to a different plan; it seems to me to be only a shorter way of arriving at the same result. There is not the same complicated system of arms, as the young is not nomadic, but is carried about by the parent. From

what I have been able to see of the development of our *Cribrella*, I should think it highly probable that the peduncle is homologous to the brachiolar appendages of the *Brachiolaria*. I would also suggest that the two modes of development, the viviparous and plutean of the *Ophiurans*, and the auricularian and the other mode of growth of the *Holothurians*, do not differ in any other way, and that future investigations will show that in all these cases the young Echinoderm is developed from the water-tubes, whether it is a nomadic or plutean mode of development, as I shall call it, or a sedentary mode of development, as we may call the second, where the eggs are carried about by the parent till the young Echinoderm has passed through the greater part of its development.

The younger stages of the larva of the *Echinus drobachiensis* do not differ, in their general features, from the mode of development of the star-fishes. We have the same water bodies formed as diverticula from the digestive cavity, the same differentiation of the digestive cavity into an alimentary canal, a stomach, and an œsophagus. This differentiation only takes place at an earlier period than in the star-fish, before the mouth is formed. However, there is nothing in the earlier stages of development of the Sea-urchin which is not applicable as well to the *Brachiolaria*.

Figs. 1 - 9. — *Asteracanthion berylinus*.

- Fig. 1. Egg of *Asteracanthion berylinus* Ag., surrounded by spermatic particles during artificial fecundation.
- Fig. 2. The yolk has divided into two segments.
- Fig. 3. The yolk has divided into eight spheres. We can already see at this early stage the tendency of the peripheric arrangement of the spheres to form an outer shell.
- Fig. 4. An embryo hatched from the egg a few hours, showing the difference in the thickness of the walls at the two poles (*a*).
- Fig. 5. The same as Fig. 4, somewhat more advanced; a depression appears at the pole (*a*) where the thickening of the walls is found. This is the first appearance of a mouth.
- Fig. 6. An embryo somewhat more advanced, in which this depression has assumed the shape of a long digestive cavity (*d*), in which the opening (*a*) performs at the same time the functions of anus and mouth.
- Fig. 7. The extremity of the digestive cavity at the time of formation of the water system, at the moment when the two water-tubes (*w*, *w'*) are about to separate from the digestive cavity (*d*), from which they arose as diverticula; they are still united in this figure.

Fig. 8. An embryo somewhat more advanced than Fig. 6, seen in profile, to show that this digestive cavity does not remain in the centre of the body, but bends towards one side, and eventually joins the wall of the lower side as seen here (*m*). This point of junction is the indication of the future mouth, after the formation of which the first mouth assumes exclusively the functions of an anus, which is also now bent down, while the anal extremity of the embryo (*a*) is slightly bevelled.

Fig. 9. An embryo of *Asteracanthion berylinus* still more advanced than Fig. 8, seen in profile; at this time the digestive cavity has been differentiated into three distinct parts,—a retort-shaped stomach, of which the bulb is the stomach (*d*), and the tube the alimentary canal, the walls of which are quite thick, while the walls of the œsophagus are quite thin and transparent, capable at the same time of great contraction and expansion. The mouth (*m*) is seen like a large opening in the middle of the depression on the lower side, leading into a pistol-shaped œsophagus. Immediately over this is seen one of the water-tubes communicating by means of a tube (*w*) with the outer medium. This opening (*b*) becomes eventually the madreporic body. On the opposite side there is a similar water-tube which has no connection with this one, and does not open outward. The two small protuberances (*v*, *v'*) on the sides of the mouth are the first signs of the chord of vibratile cilia.

Figs. 10–18. — *Asteracanthion pallidus*.

Fig. 10. A young embryo of *Asteracanthion pallidus* seen from the mouth side, to show the position of the two water-tubes (*w*, *w'*), and also the manner in which the vibratile cilia commence as two independent arcs on each side of the mouth. The broad œsophagus is also seen leading into the round stomach (*d*), which empties through a narrow alimentary canal (*c*), through an anus (*a*) placed near the upper arc of vibratile cilia.

Fig. 11. An embryo in which all the parts of the Brachiolaria can already be detected. (Compare with Fig. 12.) The two simple arcs of vibratile cilia have formed two independent plastrons, the corners and indentations of which are the first traces of the future arms (*e'*, *e''*, *e'''*, *e''''*). The two independent water-tubes of the preceding figure have increased in size; they now extend beyond the level of the mouth, and form a broad Y-shaped body, which surrounds the œsophagus (*o*) and extends from the mouth to the opposite extremity of the stomach.

Fig. 12. A Brachiolaria in which the corners of the vibratile chord of the embryo of the preceding figure have developed into long arms (*e'*, *e''*, *e'''*...). There are also three small heavy appendages (*f*, *f''*), surmounted by short warts, which did not exist in the other figures, situated at the extremity opposite to that where the young echinoderm is developed. Branches of the water system (*f''*) enter into these arms, as shown in the following

figure (Fig. 13), in which the embryo is seen in profile. This figure represents it from the mouth side. We see on the left of the stomach the open curve of the tentacles (*st*), while on the other side the beginning of the abactinal region (*r*) is visible. The tentacles are formed, as is clearly seen in this figure, by the folds of the walls of the water-tube of one side; while the abactinal area (*r*) is developed on the surface of the water-tube placed on the opposite side. The large opening (*w*) on the right of the stomach is a branch of the water system which passes out on the opposite side, under the intestine, between it and the stomach.

Fig. 13 is Fig. 12, seen in profile. It shows the course of the vibratile chord, the position of the rudimentary tentacles (*st*) of the young star-fish, the shape of the œsophagus (*o*) and its position, hanging down between the Y shanks of the water system. The position of the branches of the water system (*f*) which pass into the brachiolar tentacles is also clearly seen.

Fig. 14 is a young star-fish (*A. pallidus*), a few hours after it has absorbed the Brachiolaria. Its irregular outline is apparent. The arms are not yet all in one plane; the young star-fish is not yet unwound.

Fig. 15. The same as Fig. 14, seen from the actinal side to show the rudimentary character of the tentacles (*t*), which are simple loops opening into a wide cavity. The mouth (*m*) of the young star-fish is movable. In this and the preceding figure the spines are simple warts, with accumulation of Y-shaped limestone particles. They are, however, arranged in regular order; the outer rows of each arm have four spines, the next three, then two, and finally a central one.

Fig. 16. A young star-fish much more advanced than Figs. 14 and 15, in which the arms are on one level, the spines quite well developed, and the tentacles extending far beyond the edge of the disc, provided with suckers. We see in this particularly well the crinoidal arrangement of the plates of limestone particles on the abactinal side. The arrangement of the spines is still regular. There are no signs of the madreporic body or of the anus on this abactinal side.

Fig. 17. The lower side of a young star-fish in about the condition (not quite as advanced) of Fig. 16, to show that the terminal tentacle (*t*, Fig. 16) never develops a sucker; but at the base of this odd tentacle, which always remains cylindrical, even in the adult, we find an eye-speck (*e*) placed on a prominent bulb. The other tentacles, as is seen in the same figure, have all suckers, and are arranged in one row on each side of the radiating tube. The position of the madreporic body (*b*) is still on the lower side, opening in the angle between two of the arms, as is seen in this figure.

Fig. 18 is a young star-fish seen in profile, to show the arched abactinal area and the mode of carrying the odd ocular tentacle (*t'*), which is always turned up. The spines are very prominent for the size of the star-fish, and in this attitude the young star-fish would readily be mistaken for a young sea-urchin.

Explanation of Lettering.

<i>a</i> , anus.	<i>f</i> , brachiolar arms.
<i>o</i> , œsophagus.	<i>f''</i> , odd brachiolar arm.
<i>m</i> , mouth.	<i>f'</i> , branch of water-tube leading
<i>d</i> , digestive cavity.	<i>f'''</i> , surface warts of <i>f''</i> . [into <i>f</i> .
<i>c</i> , alimentary canal.	<i>s</i> , actinal region.
<i>w</i> , water-tube. [body.	<i>r</i> , abactinal region.
<i>w'</i> , water-tube leading to madreporic	<i>t</i> , tentacles.
<i>w w'</i> , point of junction of <i>w</i> and <i>w'</i> .	<i>t'</i> , odd terminal tentacle of star-fish.
<i>b</i> , madreporic body or suture of the	<i>e</i> , eye of star-fish.
arms. [larva.	<i>v</i> , vibratile chord, anal part.
<i>e', e'', e''', e'''', e^s, e^s</i> , arms of Brachio-	<i>v'</i> , oral portion of vibratile chord.

Professor Peirce and Mr. Winlock made a communication upon the remarkable auroral arch seen on Thursday evening, the 9th instant.

Professor Lovering made the following communication

On the Velocity of Light, and the Sun's Distance.

Foucault's recent experiment on the velocity of light, though of a less popular character than his celebrated pendulum-experiment to prove the earth's rotation, will, nevertheless, attract even more attention among men of science. If its results are placed beyond doubt, they will affect Astronomy to a degree not possible for the pendulum-experiment, unless it had come as early as the time of Galileo. I shall examine Foucault's investigation on the velocity of light : 1st, as it influences the science of Optics ; and 2d, as it tells upon one at least of the vexed questions in Astronomy.

In the circle of the sciences the centre may be placed anywhere, and the circumference will be everywhere ; such is the natural dependence of each upon all the rest. The child even may become father of the man. After the science of Optics had furnished Astronomy with the telescope, the astronomer discovers with it the satellites of Jupiter and the aberration of light, and with the help of these phenomena assigns the value of the velocity of light, and thus repays to Optics the debt incurred by his own special science. Now for the first time the science of Optics has relinquished the guardianship of Astronomy ; ascertained by direct experiment one of its own fundamental data, and thereby, possibly, put Astronomy under a new obligation, to be cancelled doubtless, with interest, hereafter.

Let us glance first at the two astronomical methods of measuring the velocity of light. While the senses of touch and taste act only by contact, those of hearing and seeing bring the mind into communication with distant objects. The air and the omnipresent ether supply the delicate and ever-ramifying threads by which telegraphic intercourse is maintained with the ear and the eye. When the origin of the sound or the light is at a large distance, compared with the velocity of the acoustic or luminous wave, allowance must be made for the time taken by the news of an audible or visible event to come to us. Only the vast spaces of Astronomy are commensurable with the great velocity of light, and furnish a sufficiently large theatre for a direct experiment upon it. But in stellar astronomy the magnificence of the extent of view so far transcends in magnitude even the velocity of light, that the luminous ray, vast as is its speed, seems to loiter upon its long way.

Hence in Astronomy a distinction exists between the *actual* interval of successive events and the *apparent* interval. For example, the first satellite of Jupiter revolves around its primary in about $42\frac{1}{2}$ hours; and, therefore, enters the shadow of Jupiter and is eclipsed once every $42\frac{1}{2}$ hours. As it takes light more than 40 minutes to pass over the average distance of Jupiter, the eclipse is not seen until so many minutes, on the average, after it has happened. If this delay were constant, the interval of successive eclipses would not be changed. But in the course of six months the distance of the earth from Jupiter increases by the diameter of the earth's orbit, and in the next six months changes back again; and when the earth is nearest to Jupiter, the news of an eclipse reaches us in about 32 minutes; whereas if the earth is at the greatest distance, 50 minutes are required. Consequently, the intervals between successive eclipses, as they exist for our eyes, are variable, being sometimes larger and sometimes smaller than the real intervals. This irregularity in the apparent intervals of the eclipses of the same satellite, at first attributed to errors of observation, finally conducted Römer in 1675 to the discovery of the velocity of light. Delambre, after discussing 1000 of these eclipses, observed between 1662 and 1802, calculated the velocity of light to be such as to require 493.2 seconds to pass over the mean distance of the sun. If this time divides 95,360,000 statute miles, which is the sun's distance as given by the transits of Venus in 1761 and 1769 according to Encke's computations, the quotient, or 193350 statute miles, is the velocity of light in a second.

The second process which Astronomy has supplied for obtaining the velocity of light may be called the indirect method. It demands not a *space*, but a *velocity* which is commensurable with the velocity of light. If two such velocities are compounded together, according to the principle of the *parallelogram of motions*, there is a resultant motion, the direction of which deviates sensibly from that even of the largest motion which enters into the composition. In nature the velocity of the earth is compounded, in this way, with the velocity of light, and imparts an apparent path to the light, differing by a small angle from the true path. The angular displacement which this causes between the apparent and real places of a star is called aberration, and was first discovered by Bradley, in 1726; this astronomer explaining, on this simple principle, anomalies in observation which had hitherto been considered accidental. As the displacement of the star works opposite ways at opposite seasons of the year, half the difference between the extreme places is the distance from the apparent to the true place, or the constant of aberration. This, when known as an observed fact, establishes the ratio between the velocity of light and the velocity of the earth, and enables the astronomer to assign the value of the one with all the accuracy which pertains to his knowledge of the other. Accepting Struve's determination of the aberration, viz. $20''.45$, the velocity of light is calculated to be 10088 times as great as the velocity of the earth. The mean velocity of the earth is known with all the certainty which belongs to our knowledge of the magnitude of the earth's orbit; that is, of the sun's distance. Assuming, as before, that the distance derived from Encke's parallax is the most reliable, the velocity of the earth in one second of solar time is $18.987+$ miles. This multiplied by the aforesaid ratio gives 191513 miles for the velocity of light by Bradley's method. It appears, therefore, that the velocities by the two methods of Astronomy (the direct and the indirect), differ by 1837 miles; a small quantity comparatively, being only *one per cent* of the whole velocity. Whatever other value is adopted for the sun's distance will alter these two results proportionally, without disturbing the ratio between them. I may add, that the velocity which aberration ascribes to light belongs to it at the earth's surface; that is, in the dense atmosphere; whereas, the velocity discovered from the eclipses is that which extends through the planetary spaces. This distinction, however, will do little towards bringing the two results into greater accordance. The velocities of light in different media are pro-

portional to the indices of refraction inversely, which in the case presented are as 1 to .000294. This theoretical difference of velocities is less than $\frac{1}{30000}$ of the whole, or less than 70 miles.

Compare with these conclusions of Astronomy two experimental results on the same subject. Although Wheatstone's experiment on the velocity of electricity, published in 1834, suggested the possibility of measuring, in a similar way, other great velocities, I shall consider first a contrivance of Fizeau, equally applicable to light and to electricity. If a wheel finely cut into teeth on its circumference is put in rapid rotation, a ray of light which escapes between two consecutive teeth will, after being reflected perpendicularly by a mirror, return to strike the wheel at a different point, and either be intercepted by a tooth, or admitted at another interstice. Suppose the velocity of the wheel just sufficient to bring the adjacent tooth to the position whence the ray first started, in the time which the light occupies in going to the mirror and returning. In this time the wheel has moved over an angle found by dividing 360° by twice the number of teeth which the wheel contains. Therefore the time taken by light in going over a line equal to twice the distance of the mirror is that portion of a second found by dividing unity by the product of the number of turns the wheel makes in a second, multiplied by double the number of teeth on the wheel; the velocity of the wheel being first made the smallest which will cause it to intercept the light. Such an experiment was made in 1849, by Fizeau, the rotating wheel being placed in a tower at Suresne, near Paris, and the mirror upon a hill (Montmartre) at the distance of 8633 metres. As the wheel contained 720 teeth, and the slowest velocity which produced obscuration was 12.6 turns a second, it appeared that light required $\frac{1}{18144}$ of a second to go 8633 metres and return. Hence the velocity was 313,274,304 metres, or 194667 miles a second. The French Academy thought so favorably of this attempt that they referred the subject to a scientific commission consisting of Biot, Arago, Pouillet, and Regnault, with authority to procure a grand machine for repeating the experiment.

When Arago advocated the claims of Wheatstone to the vacant place of corresponding member of the French Academy in the section of Physics, it was objected that Wheatstone had only made a single experiment, without having discovered a principle. Arago engaged to prove that the candidate had introduced a fertile method of experimentation, which would be felt in other sciences as well as electricity.

For example: the corpuscular theory of light requires that the velocities of light in different media should vary directly as the indices of refraction, whereas the undulatory theory inverts this ratio. Arago prepared for the trial by experiments on rapid rotations, the mechanical difficulties to be overcome, and the comparative advantage of slower rotations, assisted by several reflections, in place of a single mirror turning with its maximum speed. Aided by the refined skill of Breguet, he realized velocities in the mirror of 1000 turns a second, and of the axis detached from the mirror of even 8000 turns. In the mean while his eyesight began to fail him, and younger physicists entered into the fruit of his labors. After Foucault and Fizeau by separate efforts had decided the question in relation to the velocities of light in air and in water in favor of the undulatory theory, and thus confirmed a conclusion which Arago reached by *diffraction* in 1838, and after Fizeau had studied the variation of the velocity of light in running water, according as the motions agree or differ in direction, Foucault was emboldened to attempt a measure of the *absolute* velocity of light by an experiment which could be brought within the compass of a single room. I translate his own account of the arrangements made for this purpose: —

“A pencil of solar light reflected into a horizontal direction by a heliostat, falls upon the micrometric mark, which consists of a series of vertical lines distant from one another $\frac{1}{10}$ of a millimetre. This mark, which in the experiment is the real standard of measure, has been divided very carefully by Froment. The rays which have traversed this initial surface fall upon a plane rotating mirror at the distance of a metre, where they suffer the first reflection, which sends them to a concave mirror at the distance of 4 metres. Between these two mirrors, and as near as possible to the plane mirror, is placed an object-glass, having in one of its conjugate foci the virtual image of the mark, and in the other the surface of the concave mirror. These conditions being fulfilled, the pencil of light, after traversing the lens, forms an image of the mark on the surface of this concave mirror.

“Thence the pencil is reflected a second time in a direction just oblique enough to avoid the rotating mirror, an image of which it forms in the air at a certain distance. At this place, a second concave mirror is placed, facing so that the pencil, once more reflected, returns to the neighborhood of the first concave mirror, forming a second image of the mark. This is taken up by a third concave mirror, and so on to the

formation of a last image of the mark on the surface of the last concave mirror of an odd number. I have been able to use 5 mirrors, which furnish a line 20 metres long for the ray to travel.

“The last of these mirrors, separated from the preceding one which faces it by a distance of 4 metres, (equal to its radius of curvature,) returns the pencil back on itself; a condition surely fulfilled, when the returning image and the original image on the last mirror but one coalesce. Then we are sure that the pencil retraces its steps, returns in full to the plane mirror, and all the rays go back through the mark, point for point as they went forth.

“This return of the pencil may be proved on an accessible image by reflecting the pencil to one side by a surface of glass at an angle of 45° , and examining it through a microscope of small power. The latter, resembling in all respects the micrometric microscopes in use for astronomical observations, forms with the mark and the inclined glass one solid piece of apparatus.

“The real image sent into the microscope, and formed by the returning rays, partially reflected, occupies a definite position in relation to the glass and the mark itself. This position is precisely that of the virtual image of the mark, seen by reflection in the glass. At least this is true when the plane rotating mirror is at rest. But when this mirror turns, the image changes its place; for while the light is going and returning between the mirrors, the plane mirror has shifted its position, and the returning rays do not strike at the same angle of incidence as when they left it. Hence the image is displaced in the direction of the rotation; and this displacement increases with the velocity of rotation; it also increases with the length of the route passed over by the rays, and with the distance of the mark from the plane mirror.

“If we call V the velocity of light, n the number of times the mirror turns in a second, l the distance between the plane mirror and the last concave mirror, r the distance of the mark from the turning mirror, and d the observed displacement, we have

$$V = \frac{8 \pi n l r}{d},$$

an expression which gives the velocity of light when the other quantities are separately measured. The distances l and r are measured directly by a rule. The deviation is observed micrometrically; it remains to show how the number of turns of the mirror n is found.

“Let us describe first how a constant velocity is imparted to the mirror. This mirror, of silvered glass, and 14 millimetres in diameter, is mounted directly upon the axis of a small air-turbine of a well-known model, admirably constructed by Froment. The air is supplied by a high-pressure bellows of Cavàillé-Coll, justly distinguished for the manufacture of great organs. As it is important that the pressure should be very constant, the air after leaving the bellows traverses a regulator, recently contrived by Cavàillé, in which the pressure does not vary by $\frac{1}{5}$ of a millimetre in a column of water of 30 centimetres. The fluid flowing through the orifices of the turbine represents a motive power of remarkable constancy. On the other hand, the mirror when accelerated soon encounters in the surrounding air a resistance, which, for a given velocity, is also perfectly constant. The moving body placed between these two forces, which tend to equilibrium, cannot fail to receive and to preserve a uniform velocity. Any check whatever, acting upon the flow of the water, allows this velocity to be regulated within very extensive limits.

“It remains to estimate the number of turns, or rather to impress on the moving body a determined velocity. This problem has been completely resolved in the following manner. Between the microscope and the reflecting glass, a circular disk is placed, the edge of which, cut in fine teeth, encroaches upon the mark and partly intercepts it. The disc turns uniformly on itself, so that if the image shines steadily, the teeth at its circumference escape detection from the rapidity of the motion. But the image is not permanent; it results from a series of discontinuous appearances, equal in number to the revolutions of the mirror; and whenever the teeth of the screen succeed one another with the same frequency, there is produced on the eye an illusion easily explained, which makes the teeth appear immovable. Suppose, then, that the disk, with n teeth in its circumference, turns once in a second, and that the turbine starts up. If by regulating the flow of air, the teeth are made to appear fixed, we are certain that the mirror makes n turns in a second.

“Froment, who made the turbine, wished to invent and construct a chronometric wheel-work to move the disk. It is a remarkable piece of clock-work, which resolves, in an elegant manner, the problem of uniform motion in the particular case in which there is no work to be done. The success is so complete, that it is my daily experience to launch the mirror with 400 turns a second, and see the two pieces of

apparatus march within $\frac{1}{10000}$ nearly of accordance during whole minutes.

"Notwithstanding the assurance I had gained in the measurement of time, I was surprised to prove in my results discordances, which were out of proportion to the precision of my means of measuring. After long research, I discovered the source of error in the micrometer, which did not allow of the degree of accuracy willingly attributed to it. To meet this difficulty, I have introduced into the system of observation a modification which amounts simply to a change of the variable. Instead of measuring micrometrically the deviation, I adopt for it a definite value in advance; suppose $\frac{7}{10}$ of a millimetre, or 7 entire parts of the image; and I seek by experiment to find the distance between the mark and the turning mirror necessary to produce this deviation; the measures extending over a length of about a metre, the last fractions have a magnitude directly visible, and leave no room for error.

"By this means the apparatus has been purged of the principal cause of uncertainty; henceforth the results accorded within the limits of errors of observation, and the means are settled in such a way, that I am able to assign confidently the new number, which appears to me to express nearly the velocity of light in space, namely, 298000 kilometres in a second of mean time."

This value reduced to statute miles shows that the velocity of light is 185177 miles in a second; which is less by 6336 miles than the velocity for light usually admitted into science, namely, the velocity obtained from the aberration of light. This discrepancy between the result of experiment, and that astronomical determination which comes nearest to it, is three times greater than the variation between the velocity deduced from aberration and that derived from eclipses.

Foucault states that the extreme difference of the results of various trials amounted to only $\frac{1}{1000}$ of the whole quantity, and that the mean result can be trusted to the fraction of $\frac{1}{5000}$. Moreover, the aberration of $20''.45$, adopted by astronomers, cannot be supposed at fault by more than $\frac{1}{18000}$ of the whole. Neither the velocity by Foucault's experiment, nor the value of aberration, can be charged with a possible error of 3 per cent, or of any error approaching to this large discrepancy. How is the new velocity of light to be reconciled with the old value of aberration? I have said that aberration establishes only the *ratio* between the velocity of light and the velocity of the earth. If this ratio cannot be tampered with, and if one term of it (the velocity

of light) must be diminished by 3 per cent, to suit Foucault's experiment, then we must at the same time diminish the other term (the velocity of the earth) proportionally; and the old ratio will be preserved and the value of aberration will be left unchanged. Is it possible, therefore, that there can be an uncertainty to the extent of 3 per cent in the velocity of the earth? If so, the tables are turned; and instead of employing the ratio which aberration supplies to calculate the velocity of light from the velocity of the earth, as the best known of the two, we henceforth must calculate the velocity of the earth from the velocity of light. For Foucault has found the latter by experiment more accurately than Astronomy gives the former. If there is an error of 3 per cent in the velocity of the earth, it is an error in space, and not in time. To diminish the velocity of the earth sufficiently by a change of time would demand an increase in the length of the year amounting to 11 days nearly.

The only other way of reaching the velocity of the earth is by diminishing the circumference of the earth's orbit, and this, if diminished, changes proportionally the mean radius of the orbit; that is, the sun's mean distance. The question, therefore, resolves itself into this. Can the distance of the sun from the earth be considered uncertain to the extent of 3 per cent of the whole distance.

The answer to this question will lead me into a brief discussion of the processes by which the sun's distance from the earth has been determined, and the limits of accuracy which belong to the received value. To see the distance of any body is an act of *binocular vision*. When the body is near, the two eyes of the same individual converge upon it. The interval between the eyes is the little base-line; the angle which the optic axes of the two eyes, when directed to the body, make with each other, is the parallax; and by this simple triangulation, in which an instinctive geometrical sense supersedes the use of sines and logarithms, the distance of an object is roughly calculated. As the distance of the object increases, the base-line must be enlarged; but the geometrical method is the same, even when the object is a star, and the base of the triangle the diameter of the earth's orbit. Substitute, then, for the two eyes of the same observer the two telescopes of different astronomers, planted at the opposite extremities of the earth's diameter, and any one will understand the principle upon which the binocular eye of science takes its stereoscopic view of the universe, and plunges into the depths of space. In this way it is that the dis-

tance of the sun from the earth is associated with the *solar parallax*, which is the angle between the directions in which two astronomers point their telescopes when they are looking at the sun at the same moment. To know the sun's distance, the astronomer studies the solar parallax. As Kepler's third law establishes a relation between the distances of the different planets from the sun and their periods of revolution, if the astronomer finds either distance by observation, the others can be computed from this law. As the horizontal solar parallax is only about 8 seconds, and an error of $\frac{1}{10}$ of a second includes an error of more than a million of miles in the sun's distance, he takes advantage of the law of Kepler, and selects a planet which comes occasionally nearer to the earth than the sun. The choice lies between Venus at inferior conjunction and Mars at opposition. The parallax of Mars may vary from $20''.7$ to $19''.1$, according to the positions of Mars and the Earth with respect to the perihelion of the orbit, at the time of opposition. The parallax of Venus at conjunction may vary, for the same reason, from $33''.9$ to $29''.9$. Venus, therefore, may be nearer to the earth than Mars, and the parallax more favorable. But Venus cannot be seen at conjunction except when its latitude is so small that a transit across the sun's disc occurs. Then the two observers refer its place, not to a star, but to the sun, and the quantity they determine is the difference of parallax between Venus and the sun, which will vary from about $21''$ to $25''$. Moreover, the difference of parallax is measured, not directly, but through the influence it produces on the duration of the transit at the two stations, and therefore upon a greatly enlarged scale.

What are the results which have been obtained, 1st, by observations of the transits of Venus, and, 2d, by observations of Mars at opposition?

1. Only two transits of Venus have occurred since the time when the sagacious Dr. Halley invoked the attention of posterity to these rare astronomical events, as pregnant with the grandest results to science; viz. those of 1761 and 1769. The astronomers of the last century did not neglect the charge which Halley consigned to them. The transit of 1769 was eminently favorable, offering a chance which comes only once in a millennium, as Professor Winthrop happily explained in his lectures on the last transits.

Whatever verdict posterity shall pronounce on the deductions from the observations then made, they will never, says Encke, reproach

astronomers or governments with negligence, or want of appreciation towards this golden opportunity. The solar parallax which Encke deduced from an elaborate discussion of all the observations, fifty years after they were made, is $8''.57116$. This corresponds to a solar distance of 95,360,000 statute miles.

Although transits of Venus will take place in 1874 and 1882, and astronomers already begin to talk of preparing for them, I have the authority of Encke for declaring that, in comparison with that of 1769, the next two transits will be so unfavorable, that nothing short of perfection in the construction of instruments, and in the art of observing, can compensate for the natural disadvantage;—so that the reduction of the possible error in the sun's parallax within the limit of the hundredth of a second is hopeless for at least two centuries more.

2. The solar parallax may also be derived from the parallax of Mars, when this planet is in opposition. In 1740, the French astronomer, Lacaille, was sent to the Cape of Good Hope, and from the parallactic angle observed between the direction of Mars, as seen from that station and from the Observatory of Paris, deduced from observations of declination, the horizontal parallax of Mars was computed, and consequently that of the sun. The solar parallax thus found was $10''.20$, with a possible error not exceeding $0''.25$. Henderson, by comparing his own observations of the declination of Mars at its opposition in 1832, with corresponding observations at Greenwich, Cambridge, and Altona, computed the solar parallax at $9''.028$.

The United States Naval Astronomical Expedition to Chili, under the charge of Lieutenant J. M. Gilliss, during the years 1849–52, had for its object the advancement of our knowledge of the solar parallax, partly by observations of Mars at opposition, and partly by observations of Venus during the retrograde portion of her orbit, and especially at the stationary points, in conformity with a method suggested by Dr. Gerling; the whole to be compared with simultaneous observations at the northern observatories. Although the observations at Chili were made on 217 nights, covering a period of nearly three years, the co-operation of northern astronomers was so insufficient that only 28 corresponding observations were made. On this account the second conjunction of Venus was useless; the other conjunction of Venus and the second opposition of Mars were of little value, and

even the first opposition of Mars led to no significant result. Dr. B. A. Gould has computed the solar parallax from the first opposition of Mars, observed at Chili, at $8''.50$.

3. The solar parallax can also be computed from the law of universal gravitation. The principle may be thus stated: The motion of the moon round the earth is disturbed by the unequal attraction of the sun on the two bodies. The magnitude of the disturbance will be in some proportion to the distance of the disturber, when compared with the relative distance of the two disturbed bodies; and this ratio of distances is the inverse ratio of the parallaxes of the sun and moon. By selecting one of the perturbations in the moon's longitude particularly adapted to this purpose, Mayer, as early as 1760, computed the solar parallax at $7''.8$. In 1824, Burg calculated this parallax, from better observations, at $8''.62$. Laplace gives it at $8''.61$. Fontenelle had said that Newton, without getting out of his arm-chair, found the figure of the earth more accurately than others had done by going to the ends of the earth. Laplace makes a similar reflection on this new triumph of theory. "It is wonderful that an astronomer, without going out of his observatory, should be able to determine exactly the size and figure of the earth, and its distance from the sun and moon, simply by comparing his observations with analysis, the knowledge of which formerly demanded long and laborious voyages in both hemispheres. The accordance of the results obtained by the two methods is one of the most striking proofs of universal gravitation." Pontecoulant makes the solar parallax by this method $8''.63$. Lubbock, by combining Airy's empirical determination of the coefficient with the mass of the moon, as he finds it from the tides, (namely, $\frac{1}{81}$), makes the solar parallax $8''.84$. If the mass of $\frac{1}{75}$ is substituted, the parallax is changed to $8''.81$. Finally, Hansen, in his new Tables of the Moon, adopts $8''.8762$ as the value of the solar parallax. Moreover, Leverrier, in his "Theory of the Apparent Motion of the Sun," deduces a solar parallax of $8''.95$ from the phenomena of precession and nutation.

The conclusions of this whole review are summed up in the following table, in which the values of the solar parallax, and of the sun's distance by the three methods of Astronomy, and by the experiment of Foucault, are placed in juxtaposition. Also the different velocities of light found by astronomical observations and by experiment.

13 *

Observer or Computer.	Method.	Parallax.	Distance.
Encke, Encke,	By Venus (1761), " (1769),	" 8.53 8.59	Miles. 95,141,830 95,820,610
Lacaille, Henderson, Gilliss and Gould,	By Mars, " "	10.20 9.03 8.50	76,927,900 90,164,110 96,160,000
Mayer, Burg, Laplace, Ponceoulant, Lubbock, Lubbock, Hansen, Leverrier,	By Moon, " " " " " " "	7.80 8.62 8.61 8.63 8.84 8.81 8.88 8.95	104,079,100 94,802,440 94,915,970 94,689,710 92,313,580 92,652,970 91,861,060 91,066,350
Foucault, Fizeau,	By Light, "	8.86 8.51	92,087,342 96,117,000
Velocity of Light, " " "	By Eclipses, By Aberration, By Fizeau's Experiment, By Foucault's Experiment,		193,350 191,513 194,667 185,177

Foucault's experiment on the velocity of light has been popularly announced as making a "revolution in astronomical science." But it appears from the preceding sketch, that it has raised no new question in Astronomy, though it may have attracted popular attention to an old difficulty, and possibly given a solution to it. The three astronomical methods present solar distances, which, even if we select the most trustworthy decision of each, differ by three or four millions of miles; that is, by three or four per cent of the whole quantity. Though the best products of the first and second methods were at one time within a million of miles of each other, an increase of lunar observations, and especially improvements in the lunar tables, have now carried that difference up to four millions of miles. If Foucault's experiment were allowed to give the casting vote, it would decide in favor of the third method; thus making the reflection of Laplace, which I have already quoted, still more memorable.

In regard to the commonly received distance of the sun, which is based upon Encke's profound discussion of all the observations made at the last two transits of Venus, the case stands thus: Encke decides from the weights of the observations, discussed in the light of the mathematical principle of *Least Squares*, that the probable error of the sun's distance, as given by the transits, does not exceed $\frac{1}{240}$ of the whole

quantity. Astronomers have also reason to believe that the adopted value of aberration is correct within $\frac{1}{1800}$ of the whole quantity. Moreover, Foucault is confident of his determination of the velocity of light within $\frac{1}{800}$ of the whole quantity; nay, he expects to improve his instruments so as to banish all errors larger than $\frac{1}{8000}$ of the whole quantity. Neither the velocity of light, aberration, nor the sun's distance, can be suspected of an error to the extent of three or four per cent, and yet one at least must be wrong to this degree, as the best values of the three elements are irreconcilable with each other. Which shall be changed?

It may excite surprise in those who have heard of the *accuracy* of Astronomy without weighing the exact significance of the word as applied to so large a subject, that there should still be a lingering uncertainty to the extent of three or four millions of miles in the sun's distance from the earth. But the error, whatever it is, is propagated from the solar system into the deepest spaces which the telescope has ever traversed. The sun's distance is the measuring-rod with which the astronomer metes out the distances of the fixed stars, and the dimensions of stellar orbits. An error of three per cent in the sun's distance entails an error of three per cent in all these other distances and dimensions. Trifling as three per cent may seem, the correction runs up to 600000 millions of miles in the distance of the nearest fixed star.

Five hundred and twenty-first Meeting.

May 12, 1863. — MONTHLY MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary (who also acted as Recording Secretary in the absence of the latter officer) read letters relative to the Academy's exchanges; also a letter from W. W. Story, Esq., now at Rome, in acknowledgment of his election as a Fellow.

Mr. Treadwell read a memoir on the effect of cannon-shot upon iron-clad ships and armor-plates generally; this being a sequel to his memoir "On the Practicability of constructing Cannon of Great Caliber," published in the sixth volume of the Academy's Memoirs (1856); the object of this sequel

being to show, that the recent application of rifling to cannon is especially advantageous for increasing the size and power of guns made upon the principle proposed by him in the former memoir.

Professor W. B. Rogers exhibited a new form of electrophorus, made of vulcanite, by Mr. Cornelius of Philadelphia, which has the advantage of working perfectly in damp as well as in dry weather. He also showed an adaptation of the same apparatus in another form, for the lighting of gas-lamps.

Professor B. Peirce discoursed on the mathematical properties of the elastic sac, which he thought had some bearing upon physiological problems.

Five hundred and twenty-second Meeting.

May 26, 1863. — ANNUAL MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary, on the part of the Council, read the following Report : —

Upon a revision by the Council of the roll of the Academy, it appears that six Fellows, two Associate Fellows, and two Foreign Honorary Members have been elected into this Society during the past year.

On the Foreign list, Christopher Hansteen was chosen to fill the vacancy left by the death of the venerable Biot, in the First Class ; and Leopold von Ranke, in place of the late Sir Francis Palgrave, in the Third Class.

The two Associate Fellows, Professor Newton and General Humphreys, are both of the First Class.

Of the six resident Fellows, four were assigned to the First Class, one to the Second, and one to the Third Class.

Nine of our members, — the same number as last year, — viz. two Foreign Honorary Members, four Associate, and three Resident Fellows, have deceased during the year, or at least since the last Annual Report was drawn up.

One of the Resident Fellows, JAMES FOWLE BALDWIN, of the section of Technology and Engineering, died suddenly, on the 20th of May, 1862, a week before our anniversary meeting.

Mr. Baldwin was born in Woburn, at the little village of New Bridge, on the 29th of April, 1782. His father, Colonel Loammi Baldwin, was a cabinet-maker and a land-surveyor. The latter occupation, more congenial to his taste, led him to the projection of plans for the internal improvement of his native county. He devised and carried to successful completion the Middlesex Canal, one of the earliest, and for the time one of the most considerable works of the kind in the United States. He was a native of the same village with Count Rumford, was his constant friend through his political trials, and under his care and that of his son Rumford's daughter, the Countess Rumford, passed the greater part of her life. James, the fourth son of Colonel Baldwin, received the usual instruction of the village school of his native town, and afterwards went to the academies in Billerica and Westford. About the year 1800 he was in Boston preparing for a mercantile life, and after a few years was established as a merchant. But the influence of his early associations with his father, and the example of his brother Loammi, who, though educated as a lawyer, had relinquished this profession for that of an engineer, stimulated his own turn for the same pursuit. When Loammi was engaged in the construction of that beautiful and massive work, the Dry-Dock at the Charlestown Navy Yard, the first of its kind in this country, James joined him, and thus commenced in earnest the work of his life.

In the year 1828, a railroad from Boston to Albany was projected, and Mr. Baldwin was one of the commission appointed by the State to make the surveys. Upon this arduous work he was employed for two years. Although the enterprise was not proceeded with at that time, yet subsequently the Western Railroad, now in operation, was built upon the location selected by him, and his plans for its construction were generally adopted. Mr. Baldwin looked upon this, next to the supply of pure water to the city of Boston, as the most important of his professional works. From 1830 to 1835, he was employed in the construction of the Boston and Lowell Railroad, and in the planning of several of the mills of manufacturing companies in this and the neighboring States. He also determined the relative amount of water-power used by the mills of the different companies at Lowell.

In 1825, the subject of supplying Boston with pure water began to attract serious attention. Different sources were investigated, and estimates made. In 1837, Mr. Baldwin was appointed on a commission still further to inquire into and recommend a plan for this object. A majority of this commission recommended the introduction of water from Spot and Mystic Ponds, — from the latter by pumping. From these sources they proposed to furnish three millions of gallons daily, a sufficient supply, as they supposed, for ten years. Mr. Baldwin dissented, and recommended Long Pond (Lake Cochituate), which would itself furnish nine millions of gallons daily, and could be materially increased from other sources in the same water-shed. He urged the adoption of a conduit of masonry instead of iron pipe, and of gravitation instead of pumping. The city authorities adopted the plan of the majority; it was submitted to a popular vote, and rejected. The project was not revived until the year 1844, when Mr. Baldwin was again on the commission. The plan proposed by him was adopted at the close of March, 1846, and the work was completed on the 25th of October, 1848. Instead of three millions of gallons daily for the first ten years, it actually delivered fifteen millions of gallons during that period. It may fairly be claimed that the city of Boston is pre-eminently indebted to the forecast, firmness, and professional skill of Mr. Baldwin for its present abundant and constant supply of pure water from Cochituate.

Although confining himself to his professional duties, and having little taste for politics, Mr. Baldwin was once elected a Senator for Suffolk, and he held the office until his appointment as Water Commissioner.

Mr. Baldwin was of commanding presence, being considerably above six feet in stature, and remarkably well-proportioned. He was dignified and affable in manners, kind and benevolent in disposition, warm and unfaltering in his friendships. Steadfast in his conviction of the right, no force could drive nor influence allure him from the path of duty. His mind was clear, but not rapid in its operations. He came to his conclusions by successive steps, carefully taken, and closely examined; but the results once reached, his confidence in them was rarely shaken. His judgment was formed upon a wide consideration of all the circumstances, rather than upon nicely balanced computations. He was more anxious that his works should abound in strength, than that they should be constructed with the least theoretical amount of material and the greatest possible economy.

NATHAN HALE, another of the oldest members of the same section, having been a Fellow of the Academy for forty-four years, died on the 8th of February of the current year.

He was born in Westhampton, Massachusetts, on the 16th of August, 1784, was graduated at Williams College in 1784, studied law at Troy, New York, was a teacher of mathematics at Phillips Academy, Exeter, New Hampshire, and settled in Boston in 1810, where he soon became a member of the Suffolk bar. On the first of March, 1814, he became the editor of the Boston Daily Advertiser, the earliest daily paper in this city; and he retained his connection with it for more than forty years. He was the first to introduce an editorial department as an essential part of a public journal; and by the justice, thoroughness, and sagacious prudence with which he managed this department, by the fairness of his criticisms, and by the discrimination and pure taste of his selections, he not only secured the confidence of the community, but did much to elevate the character of journalism. A journal more entirely reliable than Mr. Hale's was not to be found. Those who have regularly read what has appeared in its columns have seldom missed any event of public importance which has occurred in either hemisphere; and any one who should now wish to get a clear, condensed, honest, and unprejudiced view of the civil, social, and literary history of the last half-century would be rewarded for the labor of examining the columns of the Daily Advertiser. Although his unceasing duties as editor, and in the public and private offices he filled, left little time for original investigation, and he may have done nothing for the advancement of science directly, he did what was not less honorable nor less deserving of respectful remembrance, by constantly availing himself of the resources of science, with which he kept himself familiar, for the advancement of the useful arts. He was the first in this State to apply the power-press to newspaper printing. He made from original sources a valuable map of New England, and an excellent manual of geography, illustrated by maps printed with common types. More than all, he took a leading part in the establishment of the railway system in New England, and in the introduction of pure water into Boston. Associated as he was, in these important works, with men of greater knowledge and skill as engineers, and more full of original suggestions, he still did as much as any one else to advance these objects, by his perseverance and devotion, by the enlarged views he was

constantly presenting in his journal, by his able advocacy of them, in both houses of the Legislature, and by the confidence reposed in his prudence, his extensive knowledge, his calm judgment, and his spotless integrity. Although, from his scrupulous delicacy, he derived no pecuniary advantage from his severe and long-continued labors in these works for the public good, and died poor, he had the pure satisfaction, in his last years, of having contributed at least as largely as any one individual to the health and welfare of his adopted city, and to the unexampled prosperity of his native State.

As a writer, Mr. Hale commanded attention and secured confidence by the purity of his style, by the clearness and exactness of his statements, by the fulness of his knowledge, and by his entire sincerity. He was always interested in the advancement of literature, and was one of the founders of the *North American Review* and of the *Christian Examiner*. He was for many years an active member of the Massachusetts Historical Society. He was a member both of the Convention of 1820, and of that of 1853, for the amendment of the Constitution of this Commonwealth.

BENJAMIN D. GREENE, whom we have lost from our botanical section, died on the 14th of October last. He was born in Demarara, during the temporary sojourn of his parents there, in the year 1793, and was graduated at Harvard College in 1812. He first pursued legal studies, for a time in the then celebrated law-school at Litchfield, Connecticut, and was duly admitted to the bar in Boston. He then studied medicine, mainly in the schools of Paris and Scotland, and took the degree of M. D. at Edinburgh in the year 1821. While pursuing these studies abroad, his scientific tastes were strongly developed, especially for Botany, which, on his return home to the enjoyment of an ample fortune, now became the favorite pursuit of his life. His retiring, contemplative, and unambitious disposition rendered him averse to the toils, and wholly indifferent to the fame, of authorship. Of him it may especially be said, that he pursued his scientific studies for the pure gratification which they afforded him; but those who knew him are well aware that no small part of that gratification came from the pleasure which he took in freely placing his observations and his collections in the hands of those who could turn them to best account for the advancement of science. Perceiving that the great obstacles encountered by the naturalist here were the want of books, and of authentic collections, he early and steadily endeavored to sup-

ply these desiderata, so far as he could, in one department, by gathering a choice botanical library, and a valuable herbarium, especially rich in authenticated specimens and in standard North American collections. These were most kindly placed at the disposal of working botanists, even those of distant parts of the country; and, to secure their continued usefulness, were at length, by gift and by bequest, consigned to the Boston Society of Natural History, — of which Mr. Greene was one of the founders, and the first President, — to which, besides, he bequeathed a large legacy in money.

In character, Mr. Greene was remarkably quiet and unobtrusive, yet highly sensible, cultivated, and discriminating. Eminently kind and disinterested, if he gave no thought to secure for himself a scientific reputation, he should all the more be remembered for the wise and considerate liberality through which he sought to promote the investigations of others in a chosen department of natural history.

Of the four Associate Fellows deceased, one of the most distinguished, ORMSBY MCKNIGHT MITCHEL, was born on the 28th of August, 1810, in Union County, Kentucky. With a scanty early education, and still more scanty material wealth, he entered the Military Academy at West Point in 1825, where he was graduated in 1829 with a class-rank of fifteenth, and where for the next two years he was Assistant Professor of Mathematics. Having resigned his commission as Second Lieutenant of Artillery, which bears the date of July 1, 1829, he studied law in Cincinnati. But he soon left the practice of it for a professorship of Mathematics and Astronomy in Cincinnati College, which he held from 1834 to 1844. By his zeal and eloquence, an enthusiasm for astronomy was created in the West, which resulted in the establishment of the Cincinnati Observatory, with its admirable equatorial telescope; the corner-stone being laid in November, 1843, in the presence of the venerable Ex-President John Quincy Adams. In July, 1846, Professor Mitchel began the issue of the "Sidereal Messenger," and he continued its publication for two years, to the benefit of popular science. He also published a work on "Popular Astronomy," and another on "The Planetary and Stellar Worlds." At his chosen observatory he applied himself to the study of the double stars in southern declination, and discovered the companion of Antares. He also measured the time of rotation of Mars. Professor Mitchel was one of the first to recognize the value of the electric method of observing Right Ascensions and Declinations, and he

devised an instrument for that purpose, which attracted the favorable attention of astronomers, and was largely discussed at meetings of the American Association for the Advancement of Science. The determination of differences of longitude by electro-magnetic signals gave a new importance to the assumed value of the velocity of electricity, which did not escape his practical mind. His mechanical skill enabled him to apply his ideas rapidly to practice, and his great independence and energy of character surmounted pecuniary restrictions which would have fatally discouraged most men. In 1836 and 1837 Mr. Mitchel was Chief Engineer of the Little Miami Railroad, and in 1848 of the Ohio and Mississippi Railroad. In 1841 he was placed upon the Board of Visitors for West Point, and in 1847-8 he was Adjutant-General of the State of Ohio. He was chosen Director of the Dudley Observatory at Albany in 1859.

As soon as the rebellion broke out, Mr. Mitchel promptly resigned the peaceful pursuits of science, in which he had achieved large honor and usefulness, and gave himself, with all the ardor of his nature, to the cause of his country. On the 9th of August, 1861, he was commissioned a Brigadier-General of Volunteers, and on the 11th of April, 1862, as Major-General in the Department of the Ohio under General Buell. At the head of an independent column, he entered Bowling Green, Kentucky, in close pursuit of the retreating rebels, and, continuing his advance southward, he seized the line of railroad between Corinth and Chattanooga, and established his forces in the north of Alabama. He was relieved of that command in July, 1862, and on the 17th of September he assumed the charge of the Department of the South. He had barely time to give promise of inaugurating a vigorous campaign, when he was seized with yellow-fever, and, after a brief illness of four days, he died at Beaufort, South Carolina, on the 30th of October, 1862, leaving to the world the memory of a name which deserves well of science and of his country.

JAMES RENWICK, our late Associate in the section of Technology and Engineering, was descended from a Scotch family, his grandfather having emigrated to the United States from Scotland. His father, William Renwick, was a merchant of New York, who married a lady of Scotland during a visit to that country. Professor Renwick was born at Liverpool in 1702, and came to this country with his parents when he was two years old. He exhibited very early in life a devotion to books, and a remarkable capacity and power for acquiring knowledge.

This is fully shown by the fact that he was sufficiently advanced to enter Columbia College at the age of eleven years, and he was graduated, at the head of a class of twenty-two, at the age of fifteen years. At the age of twenty-one, he was appointed provisionally to the chair of Chemistry. Shortly after this he became a trustee, and in 1820, at the age of twenty-eight, he was appointed to the Professorship of Natural and Experimental Philosophy and Chemistry, a chair which he filled for the long period of thirty-three years. During this time his lectures embraced Natural and Experimental Philosophy, Chemistry, Geology, Mineralogy, Practical Mechanics, and for a long period Astronomy; and he was able, by his unfaltering industry and great memory, to master and communicate to his classes a knowledge of the most important discoveries made through these vast fields of science. In the year 1838 he was appointed one of the Commissioners for the survey of the Northeastern Boundary, and his letters to a distinguished friend in England are said to have had much influence in preparing for the subsequent diplomatic arrangement upon that subject. As a writer, Professor Renwick is known by several treatises on Chemistry and Mechanics. He likewise wrote somewhat elaborate biographies of Fulton, Rittenhouse, and DeWitt Clinton, not to mention large contributions to various reviews and scientific journals. To this array of Professor Renwick's wide acquirements and labors we must not omit to add, that his taste for the fine arts was highly cultivated, and his critical knowledge, especially of painting, often referred to as exact and authoritative.

Although Professor Renwick made no great discovery by which the boundaries of science were enlarged or the mastery of man over nature increased, yet the influence exercised by his full mind upon a very large and active community was extensively felt, and tended greatly to the advancement of knowledge and the arts. He died at his residence in New York, after a short illness, on the 12th of January, having nearly completed his seventy-first year.

CHARLES WILKINS SHORT, M. D., one of the pioneers of Botany in the Western States, died at his residence near Louisville, Kentucky, on the 7th of March last, in the sixty-ninth year of his age. He was born in Woodford County of that State, in October, 1794, took his medical degree from the University of Pennsylvania in the year 1815, was called to the chair of Materia Medica and Botany in Transylvania University in 1825, and to the same chair in the new University at

Louisville in 1838, fulfilling his duties as Professor with assiduity and success until the year 1849, when he retired from public functions. He was for many years one of the conductors of the *Transylvania Journal of Medicine*, to which he contributed numerous scientific papers, mostly relating to the botany of his native State. Dr. Short's influence upon the advancement of the science to which he devoted himself was more considerable than would be inferred from the extent of his publications. He was a keen observer, a diligent explorer, a liberal promoter of the explorations of others, and a bountiful correspondent. There are few herbaria of consequence in this country or in Europe that have not been enriched by choice contributions from his hands. He and the late Mr. Oakes, independently, and at nearly the same period, seem to have invented the art of preserving perennially in dried specimens almost all the beauty and attractiveness, and the scientific usefulness, of the living originals. The frequent recurrence of his name in the pages of the systematic botanical works of the last thirty years testifies to his scientific industry. His faults were an unwarrantable diffidence, a too fastidious taste, and the total absence of personal ambition, together conspiring to limit unduly his endeavors in the fields of original investigation and authorship.

EDWARD ROBINSON, our late eminent Associate in the section of Philology and Archæology, belongs to that not inconsiderable class of men who are led into a literary career by their decided taste, by their inner prompting, and in spite of outward impediments. Born on the 10th of April, 1794, in Southington, Connecticut, where his father was settled as a parish minister, he attended first the common school of his native town, and then a private school, kept by a clergyman. In his sixteenth year he was apprenticed to a merchant; but a year later, after many fruitless efforts, he overcame the opposition of his father, and obtained permission to enter Hamilton College, in the State of New York. Here he pursued his studies, chiefly under the guidance of his maternal uncle, one of the Professors, and graduated in 1816. He now entered the office of a lawyer in Hudson; but within a year he accepted an appointment as a Tutor in Hamilton College, where he taught Mathematics and Greek. In 1818 he married the daughter of the well-known missionary to the Indians, Samuel Kirkland. She died within the year. He remained in charge of the farm belonging to her, and devoting himself also to classical studies, until 1821, when he went to Andover, where, without becoming a regular

member of the Seminary, he studied theology, and became in 1823 one of the teachers of the institution. He translated at that time Wahl's *Clavis Novi Testamenti*, and, in connection with Professor Stuart, Winer's Grammar of the Language of the New Testament.

Full of admiration of thorough German scholarship, he determined to pursue his studies in Europe, whither he went in 1826, and devoted himself, first at Paris, but chiefly at Halle and Berlin, to Biblical and Oriental studies. At Halle he married the youngest daughter of Professor Von Jacob, a lady known to the public by her *nom de plume* of Talvi. After a residence of four years, which was of incalculable influence upon his succeeding career, and after extensive travels in Europe, he returned in 1830 to this country, and was immediately made Assistant Professor and Librarian at the Theological Seminary at Andover. While yet in Germany, he had translated the large Greek Grammar of Buttmann, which was published immediately after his return. He was one of the founders of the Biblical Repository, and for several years a principal contributor to its pages. In 1833 the state of his health induced him to resign his office at Andover, and remove to Boston. Here he was particularly occupied with the preparation of a new Greek-English Dictionary of the New Testament, and a translation of Gesenius's Hebrew-Latin Lexicon. Both were published in 1836. In the following year he accepted the professorship of Biblical Literature in the newly-established Theological Seminary in the city of New York, on condition of being permitted to visit Europe once more. Revisiting Germany, he now, according to a plan cherished and matured for fifteen years, with the late Dr. Eli Smith, the well-known missionary at Beirût, made a journey to Egypt and Palestine. Returning from his travels in the autumn of 1838, he took up his residence in Berlin, where he remained until August, 1840, to elaborate the results of his researches in his celebrated work, entitled "Biblical Researches in Palestine and Adjacent Countries," which appeared simultaneously in Germany and England. Of this work, Karl Ritter said : " It will occupy one of the most important places for the study of geographico-antiquarian sources of the Scriptures : it will, on account of the many new discoveries and investigations it records, be of enduring value for our knowledge of the Orient, and will furnish the data for an entire reconstruction of the cartography of Palestine, hitherto so imperfect."

Returning now to America, he commenced his official labors in the

Union Theological Seminary in New York, and continued them until 1852, when he undertook a second visit to Palestine, for the purpose of re-examining many points discussed in his work. It was his intention to give the results of these extensive, patient, and thorough researches in a work entitled "A Physical and Historical Geography of the Holy Land." A few years ago, his literary labors were seriously interrupted by the formation of a cataract; and as his health as well as his sight had suffered in consequence of an unsuccessful operation, he last summer sought medical advice in Europe, from which he returned in October last. He died in New York, in January, in the sixty-ninth year of his age.

Dr. Robinson's residence at a distance from Boston prevented him from taking that active part in the doings of this Academy which he undoubtedly would have done had he lived among us. Different was his relation to another association, the Oriental Society, of which he was one of the original members, and, after the death of the lamented Mr. Pickering, its President. That Society enjoyed the great advantage of being represented by one whose position in the republic of scholars all over the world was recognized and appreciated; and it will be no easy task for any one to fill as honorably and successfully the place occupied by him for seventeen years.

After this brief sketch of Dr. Robinson's labors, it is unnecessary to speak of his character as a scholar. His works speak for him. If any one characteristic were to be mentioned as pre-eminent, it would be that of thoroughness,—thoroughness in investigating, thoroughness in considering and maturing, thoroughness in elaborating the subjects of his choice. This quality was conspicuously shown in the manner in which he prepared himself for his first visit to Palestine. He understood the whole ground,—he made himself familiar with all that had been written and done up to that time,—he consulted every scholar in this country and Europe from whom he could expect to receive useful hints. And, not satisfied with his first explorations, large and valuable as they were, his irresistible desire of exhausting, if possible, his subject, led him to undertake a second visit. The same quality of thoroughness was illustrated in another way. Although to him the knowledge of the German language was merely a means to the end,—an instrument,—it would be very difficult to find an American or Englishman who had mastered that language so thoroughly, and entered so deeply into its spirit and essence.

SIR BENJAMIN COLLINS BRODIE, Bart., a Foreign Honorary Member of this Academy, and recently President of the Royal Society, died, October 21st, 1862, at the ripe age of eighty years. Of that remarkable trio of British surgeons of this century, distinguished alike for their high professional and scientific attainments, Sir Astley Cooper, Sir Benjamin Brodie, and Mr. William Lawrence, the latter now alone remains. Sir Benjamin Brodie was born at Winterslow, Wiltshire, June 9th, 1783. He commenced the study of medicine in London, under the distinguished anatomists Wilson and Thomas, at the Hunterian School of Anatomy, in Great Windmill Street, and subsequently became the pupil of Sir Everard Home, and at a later period his assistant. His first scientific paper was a communication made to the Royal Society, through Sir Everard Home, in 1809, the year before his election as a Fellow of the Society. During the next five years he published in the *Philosophical Transactions* a series of papers giving the results of experimental researches upon the agency of the brain in maintaining the heart's action, in the processes of secretion, and in the production of animal heat; upon the mode of action of poisons on the animal economy; and upon the influence exerted by the pneumo-gastric nerve over the secretions of the alimentary canal. These papers gained for him European fame as a physiologist. But great as was his success in this department of science, he yielded to the increasing demands of practice, and devoted his whole energies to his chosen pursuit of surgery. He nevertheless always retained a deep interest in the subjects of these early investigations, and after his retirement from active practice he collected his *Physiological Essays* in a volume, which he republished in the year 1851, with corrections and additions.

His first and most important contribution to surgery is his classical "Observations on the Diseases of the Joints," the first outlines of which appeared in the *Medico-Chirurgical Transactions* for 1813 and the two subsequent years, and of which five editions were published, the last revised, and in part rewritten, in the year 1850. When he undertook this work, the whole subject was involved in the greatest confusion, and the terms "white-swelling," "scrofulous joints," &c. "were used without any well-defined meaning, and almost indiscriminately, so that the same name was frequently applied to different diseases, and the same disease distinguished by different appellations." This confusion he unravelled, and first established the indications of treatment upon the firm basis of accurate diagnosis.

His next surgical work was a course of "Lectures on the Diseases of the Urinary Organs," published in the year 1832; it has gone through four editions, and is still one of the standard works on that subject. In these lectures he considered the operation of lithotrity, which had been performed for the first time upon the living subject by the distinguished Civiale eight years before, and which had been brought to perfection by the improved instruments of Ammusat and Heurteloup. The novel idea of crushing the stone in the bladder, as a substitute for its extraction by a cutting operation, encountered bitter opposition from many of the leading surgeons of the day, who had acquired great dexterity in the performance of lithotomy, and therefore regarded with distrust the new method, which threatened to supersede it. Brodie treated the subject in the spirit of a philosopher, and gave it as his opinion that lithotrity might ultimately take the place of the older operation; and he lived, not only to see it used by others, but to employ it himself with perfect success. In fact, with the exception of a few special cases, as in young children, in whom lithotomy is an operation of comparatively little danger, and in cases of very large or very hard calculi, and perhaps in a few other instances, lithotrity is now the regular method.

A third surgical work, published in 1837, is devoted to the study of certain painful affections, principally of the joints, which occur, for the most part, in women, and in those who are more or less under the influence of the nervous system. In these "Hysterical Affections of the Joints," he showed that there is little or no local disease, and that the violent and protracted local treatment formerly in vogue, and which often ended in amputation, ought to be altogether abandoned, and the disease treated by constitutional remedies of a tonic and invigorating character.

Sir Benjamin's last work, and that by which he is best known to literary and scientific men in general, is his "Psychological Inquiries, being a Series of Essays intended to illustrate some Points in the Physical and Moral Nature of Man." In this charming work he lays open, in the familiar form of dialogue, the operations of his own vigorous intellect, and displays that rare combination of sound judgment with the highest powers of observation which constitutes the true philosopher. Writing less than many others, he wrote more; for every sentence is pregnant with meaning, and every well-established premise leads to the wisely-drawn conclusion.

Sir Benjamin Brodie has been Professor of Anatomy and Surgery to the Royal College of Surgeons, and was at one period of his life Surgeon to St. George's Hospital. He was Surgeon to King George IV., and Sergeant-Surgeon to King William IV., in whose reign he was created a baronet. He was afterwards Surgeon to H. R. H. Prince Albert, and Sergeant-Surgeon to her present Majesty Queen Victoria.

The actual list of the Academy, as recently revised, will be found appended to the new half-volume of the Memoirs, which now lies upon the table. It will be seen that there are at the present time 164 Resident Fellows, 82 Associate Fellows, and 72 Foreign Honorary Members.

In conclusion, the Council presented to the Academy certain nominations.

The Treasurer read his annual report, which was accepted and ordered to be entered on the records.

Professor Lovering, the Chairman, read the report of the Committee of Publication, which was accepted and ordered to be placed on file.

Dr. Beck offered two resolutions, proposing to request the American Minister in Italy to use his influence, on the earliest opportunity, in furtherance of such changes in the administration of the Vatican Library as will enable students to consult it. With the assent of the mover, the resolutions were referred to the Council.

The annual election took place, and the following officers were chosen for the ensuing year:—

ASA GRAY, *President*.

CHARLES BECK, *Vice-President*.

WILLIAM B. ROGERS, *Corresponding Secretary*.

CHAUNCEY WRIGHT, *Recording Secretary*.

EDWARD WIGGLESWORTH, *Treasurer*.

JOSIAH P. COOKE, *Librarian*.

Council.

THOMAS HILL,	} of Class I.
GEORGE P. BOND,	
JOHN B. HENCK,	
AUGUSTUS A. GOULD,	} of Class II.
LOUIS AGASSIZ,	
JEFFRIES WYMAN,	
ROBERT C. WINTHROP,	} of Class III.
GEORGE E. ELLIS,	
HENRY W. TORREY,	

Rumford Committee.

JOSEPH LOVERING,	JOSEPH WINLOCK,
MORRILL WYMAN,	CHARLES W. ELIOT,
WILLIAM B. ROGERS,	THEOPHILUS PARSONS,
CYRUS M. WARREN.	

Committee of Finance.

ASA GRAY,	} <i>ex officio</i> , by statute.
EDWARD WIGGLESWORTH,	
J. INGERSOLL BOWDITCH, by election.	

The other Standing Committees, appointed on nomination from the chair, are as follows:—

Committee of Publication.

JOSEPH LOVERING,	JEFFRIES WYMAN,
CHARLES BECK.	

Committee on the Library.

AUGUSTUS A. GOULD,	WILLIAM P. DEXTER,
JOHN B. HENCK.	

Committee to audit the Treasurer's Accounts.

THOMAS T. BOUVÉ,	CHARLES E. WARE.
------------------	------------------

Mr. Safford presented the following paper : —

On the Observed Motions of the Companion of Sirius. By
T. H. SAFFORD, Assistant at the Observatory of Harvard
College.

It is well known to astronomers that the motions of the bright star Sirius indicated the presence of a disturbing body, before the discovery of a companion by Mr. Alvan Clark. It was shown by Bessel,* that there were irregularities in the motion of this star in right ascension which were only to be explained by the presence of an unseen companion; unless, indeed, we might permit ourselves to doubt the universality of the law of gravitation. C. A. F. Peters,† some years later, computed such of the elements of the motion of Sirius around the centre of gravity of the system as could be deduced from the motions in right ascension; and Schubert‡ pointed out that there was some reason to believe that the motion in declination also was irregular, though he seems to have fallen into the error of supposing that the motions in right ascension and declination were not completed in the same period.

Afterwards M. Laugier,§ of the French Institute, represented the observations of Sirius in declination from 1690 to 1852 by a formula of interpolation which I fear we must consider erroneous. Laugier gives a certain weight to Flamsteed's position from the *Historia Cœlestis Britannica*, which is known to have been reduced (and probably from a single observation), without regard to aberration or nutation; so that it cannot be depended upon within 15'', while the real irregularities of Sirius's motion in declination are less than 2''.

Calandrelli,¶ Director of the Pontifical Observatory ** at Rome, has in several places insisted that the Greenwich Twelve-Year Catalogue was in error by about 3'' for the date 1845. This, however, was shown by Main †† to be contradicted by the several years' work; and I pre-

* *Astronomische Nachrichten*, Nos. 514, 515, 516.

† *Ibid.*, Nos. 745, 746, 747.

‡ *Astronomical Journal*, Vol. I. p. 154.

§ *Astronomische Nachrichten*, No. 1142.

¶ *Atti dell' Accademia Pontificia de' Nuovi Lincei*, 5 Aprile, 1853, p. 316, and elsewhere.

** This is not to be confounded with the observatory of the Collegio Romano.

†† *Monthly Notices of the Royal Astronomical Society*, Vol. XX. p. 202.

sume most astronomers would agree in considering Calandrelli's argument as irrelevant.

In No. 28 of Professor Brünnow's valuable "Astronomical Notices" I have shown that, in spite of the misapprehensions to which I have just alluded, the observed motion of Sirius in declination is in fact represented by a formula depending on the previous investigation of Peters, but with four new unknown quantities inserted. The addition of these four quantities, which I have determined by least squares, enables us to state with a certain degree of accuracy the angle of position of the centre of gravity with respect to the visible mass, and thus the angle of position of the supposed invisible companion.

Closely following the actual publication* of this memoir, came the discovery† of the companion by Mr. Clark. The question at once arose, whether this were the disturbing body; the evidence bearing upon this appeared very noteworthy. In the first place, the angle of position agreed (within the uncertainty of observation) with that computed for the disturbing body, assuming my investigation‡ as the basis. The following table shows the relation for 1862 between computation and observation. To my own computation I have added the similar one of Auwers, published afterwards.§

Computed by Auwers,	1862.1	97°.3
" Safford,	1862.1	83.8 (yearly diminution 1°.4)
Observed by Bond,	1862.2	84.6
" Chacornac, ¶	1862.2	84.6
" Lassell, **	1862.3	83.8
" Rutherford, ††	1862.2	85.0

The difference between Dr. Auwers's theoretical investigation and my own is perhaps not larger than the uncertainty of all the series of observations on Sirius would explain; as I have before stated, the

* The number bears date, Dec. 20, 1861; my own communication, Sept. 20th.

† Jan. 31, 1862. First announced by Professor Bond, in No. 1353 of the *Astronomische Nachrichten*.

‡ This fact was stated by Professor Bond (*American Journal of Science* for March, 1862, p. 287).

§ *Astronomische Nachrichten*, No. 1371. It is proper for me here to express my sense of the courtesy with which Dr. Auwers admitted my priority in the matter

|| *Astronomische Nachrichten*, No. 1374.

¶ *Ibid.*, No. 1355.

** *Ibid.*, No. 1360.

†† *American Journal of Science*, May, 1863, p. 407.]

amount of deviation from which the angle of position was computed is very small.

But that the companion of Sirius may produce the disturbances, it, the faint object barely visible in the largest class of telescopes, must have a mass nearly *two thirds* that of Sirius itself. It is difficult to believe this; but, as the evidence of this year (1863) shows, we may be compelled to do so.

There are three hypotheses logically possible with respect to the new star. It may be either unconnected with the system of Sirius, or, secondly, a satellite but not the disturbing body, or, thirdly, the disturbing body itself. On the first hypothesis, the proper motion of Sirius itself would put it in the following position, assuming the angle of position $84^{\circ}.5$, for 1862.2, and distance $10''.19$ for the same date, the latter being the mean of these results (excluding Lassell's $4''.92$, which is quite wrong).

10.09	Rutherford,*
10.07	Bond.†
10.41	Chacornac.‡

Position and Distance by Hypothesis I.; assuming the little star to be fixed.

1863.0	$79^{\circ}.1$	$10''.80$
1864.0	73.3	11.69

The second hypothesis gives no ground for calculation, and it will be considered further on.

The third hypothesis would give (correcting my own investigation, so as to agree in 1862.2 with observation, by $+0^{\circ}.9$).

1863.0	$83^{\circ}.5$
1864.0	82.1

Observation gives, compared with these hypotheses,

1863.3	Bond,§	$82^{\circ}.8$	Hyp. I.	$77^{\circ}.4$	Hyp. III.	$83^{\circ}.1$
1863.2	Rutherford,	81.2		77.9		83.2
Computed — Observed.						
			I.	III.		
Bond,			— 5.4	+ 0.3		
Rutherford,			— 3.3	+ 2.0		

* American Journal of Science for May, 1863, p. 407.

† Astronomische Nachrichten, No. 1374.

‡ Ibid., No. 1355.

§ MS. furnished by Professor Bond.

|| As before, American Journal of Science for May, 1863, p. 407.

To which must be added, that the first hypothesis requires an increase of distance between 1862.2 and 1863.2 of $0''.8$; the third, a very slight diminution; but observation indicates a diminution of about $0''.55$, a quantity, to use Mr. Rutherford's expression,* "so small that its existence cannot be asserted with confidence." It is hardly conceivable that the long and careful series of observations of Mr. Rutherford should be in error $3''.3$; and also inconceivable that Professor Bond's measures, agreeing as they do within $2^\circ 20'$ among themselves, should be in the mean $5''.4$ erroneous.

We have, therefore, nothing to oppose to the hypothesis that the new companion is the disturbing body, but the very improbable supposition that the *small star partakes very nearly in the great proper motion of Sirius without physical connection*; or the second hypothesis, that the new star is in the system, but with small mass. If this is the case, the disturbing body must, in lieu of the small light of the companion, have still less, or even be absolutely invisible. *It is consequently highly probable that the disturbing body has been actually found; that what was predicted by theory has been confirmed by sight.* The importance of continued observations on Sirius cannot be too highly felt. The companion must be measured the coming year, and for several years; while Sirius itself should be re-observed with meridian instruments. So far as the right-ascension element is concerned, a series of observations is now in progress at Cambridge; while Captain Gilliss has most obligingly consented to make a series of declination-observations at Washington; and the standard observatories at Greenwich and Paris will doubtless continue their series of fundamental star observations, including, of course, Sirius.

I am much obliged to Mr. Rutherford for the communication of the details of his observations in 1863, and hope he will publish them, together with similar details of those of 1862, and others to be made hereafter. The subject is one where the co-operation of several observers is desirable. Full certainty here can only be obtained after several years' observations.

On motion of the Corresponding Secretary, the meeting was adjourned to Tuesday, the 9th of June.

* As before, American Journal of Science for May, 1863, p. 407.

Five hundred and twenty-third Meeting.

June 9, 1863. — ADJOURNED ANNUAL MEETING.

The PRESIDENT, on taking the chair, addressed the Academy as follows : —

I cannot with justice to myself take this chair, and enter upon its honorable duties, without saying that, while I defer to the will of the Academy, as expressed by your suffrages, my best judgment does not altogether approve the choice. I sincerely wished that your choice might fall upon an older member of our society, and, so far as I properly could, I had used my endeavors in that behalf.

For myself, having now for seventeen years served the Academy in a responsible station, I had thought that I might, at least for a time, be released from active official duties here. You have decided otherwise, probably thinking more highly than they deserve of my efforts to serve the Academy in a subordinate administrative office.

It is to be feared, however, that, while relying, as you may, upon my activity and unceasing interest in the Academy, you have overestimated any qualifications I can bring to this chair. Nor can you reasonably expect in me the mature wisdom, and the wide general knowledge, and the calm and sure judgment, which have dignified the administration of a long line of illustrious Presidents, and which you have seen exemplified in that of my immediate predecessor.

Under these circumstances, while keenly alive to the responsibilities, I am profoundly sensible of the honor, which you have conferred upon me. I can only say that, relying both upon the considerate indulgence and the hearty co-operation of all my colleagues, I will constantly endeavor, during my term of office, to discharge the duties of President with assiduity and entire impartiality, and will thus do what I may to promote the harmony and maintain the honor and the efficiency of this society.

Just twenty years hence the Academy will complete its century of existence. Many, perhaps very many of us, will have passed off the stage before that day. But it is fairly to be expected that a large majority of our younger Fellows may take part in the centenary celebration. Let us hope, and let us all endeavor while we may, that these coming years shall be years of active usefulness, and of continued and ever-increasing prosperity, to the American Academy of Arts and Sciences.

The Corresponding Secretary read letters relative to the exchanges of the Academy.

Professor Jeffries Wyman, with some prefatory remarks, moved the following votes : —

Voted, That the members of the American Academy of Arts and Sciences bear in grateful remembrance the eminent services of their retiring President, Dr. Jacob Bigelow, who has so long discharged every duty with dignity and honor, who has presided over their counsels and deliberations so courteously and justly, and who has adorned the office and the Academy with his varied attainments in literature and science.

Voted, That the thanks of the Academy are hereby respectfully tendered to Professor Daniel Treadwell, for the constancy with which he has devoted himself to its interests, for his valued contributions to its memoirs, and for his uniform urbanity and fidelity in the performance of the duties of the office of Vice-President, which he has honorably filled for many years.

Voted, That the thanks of the Academy be also tendered to the late Corresponding Secretary, Professor Asa Gray, and especially to the late Recording Secretary, Dr. Samuel L. Abbot, for the ability, accuracy, and zealous diligence with which they have fulfilled the exacting duties of their respective charges.

They were seconded and supported by Mr. Winthrop and by Professor William B. Rogers, and were unanimously adopted.

On motion of Mr. Winthrop, copies of these votes, attested by the Recording Secretary, were ordered to be presented to the retiring officers to whom the votes relate ; and the votes were ordered to be published in the Daily Advertiser.

The Librarian read his report on the condition of the Library ; which was accepted, and ordered to be placed on file.

On motion of the Treasurer, in behalf of the Finance Committee, votes were passed appropriating eleven hundred dollars for the general expenses of the current year, seven hundred dollars for publications, and five hundred dollars for the Library.

On motion of Professor Parsons, the Treasurer was requested

to consider and report on the best method of holding and accounting for the trust funds of the Academy.

Upon the suggestion of the President, the Corresponding Secretary, the Chairman of the Committee of Publication, and the Librarian, were appointed a committee to consider the subject of the distribution of the publications of the Academy, and to report at a future meeting.

DONATIONS TO THE LIBRARY,

FROM MAY 22, 1862, TO MAY 26, 1863.

Boston Society of Natural History.

Proceedings. Vol. VII. and VIII. 8vo. Boston. 1861 - 62.

Journal. Vol. VII. No. 2 and 3. 8vo. Boston. 1861 - 62.

Trustees of the Public Library of the City of Boston.

Index to the Catalogue of Books in the Upper Hall of the Public Library of the City of Boston. 1 vol. Roy. 8vo. Boston. 1861.

Index to the Catalogue of a Portion of the Public Library of the City of Boston arranged in the Lower Hall. 1 vol. Roy. 8vo. Boston. 1858.

Tenth Annual Report of the Trustees of the Public Library. Nov. 1862. 8vo pamph. Boston.

Massachusetts Historical Society.

Collections. Vol. VI. 4th Series. 8vo. Boston. 1863.

Proceedings. 1862 - 63. 8vo. Boston. 1863.

Astronomical Observatory of Harvard College.

Annals. Vol. III. 4to. Cambridge. 1862.

Essex Institute.

Proceedings. Vol. II. 8vo. Salem. 1862.

American Antiquarian Society.

Proceedings of the American Antiquarian Society, at the Hall of the American Academy in Boston, April 30, 1862. 8vo pamph. Boston. 1862.

American Oriental Society.

Journal. Vol. VII. No. 2. 8vo. New Haven. 1862.

Portland Society of Natural History.

Proceedings. Vol. I. Part 1. 8vo. Portland. 1862.

Lyceum of Natural History, New York.

Annals. Vol. VII. No. 10-12. 8vo. New York. 1861.

Academy of Natural Sciences, Philadelphia.

Journal. New Series. Vol. V. Part 2 and 3. 4to. Philadelphia. 1862-63.

Proceedings. Vol. XIV., Vol. XV. No. 1 and 2. 8vo. Philadelphia. 1862-63.

American Philosophical Society.

Transactions. Vol. XII. Part 1, 2, 3. 4to. Philadelphia. 1862-63.

Proceedings. Vol. IX. No. 67, 68. 8vo. Philadelphia. 1862.

Philadelphia College of Pharmacy.

American Journal of Pharmacy. Ser. 3. Vol. X, XI. No. 1-3. 8vo. Philadelphia. 1862-63.

Smithsonian Institution.

Smithsonian Miscellaneous Collections. Vol. I.-IV. 8vo. Washington. 1862.

Results of Meteorological Observations, made under the Direction of the United States Patent-Office and the Smithsonian Institution, from the Year 1854 to 1859, inclusive; being a Report of the Commissioner of Patents made at the First Session of the Thirty-sixth Congress. Vol. I. 4to. Washington. 1861.

Catalogue of Publications of the Smithsonian Institution. Corrected to June, 1862. 8vo pamph. Washington. 1862.

Annual Report of the Board of Regents of the Smithsonian Institution for the Year 1861. 8vo pamph. Washington. 1862.

U. S. Naval Observatory.

Astronomical and Meteorological Observations made at the United Naval Observatory during the Year 1861; Commander J. M. Gillis, U. S. N., Superintendent. 4to. Washington. 1862.

Academy of Science, St. Louis, Missouri.

Transactions. Vol. II. No. 1. 8vo. St. Louis. 1863.

California Academy of Natural Sciences.

Proceedings. Vol. II. 1858-62. 8vo. San Francisco. 1863.

Royal Society of London.

Philosophical Transactions for the Year 1861. 4to. London. 1862.

Proceedings. Vol. II. No. 47, 48; Vol. XII. No. 49-54. 8vo. London. 1862-63.

List of Fellows. 1861. 4to pamph. London.

Astronomical and Magnetical and Meteorological Observations made at the Royal Observatory, Greenwich, in the Year 1860. 4to. London. 1862.

Geological Society.

Quarterly Journal. Vol. XVIII. Vol. XIX., Part 1. 8vo. London. 1862 - 63.

List of the Society, November 1st, 1862. 8vo pamph. London.
Charter and By-Laws, 1862. 8vo pamphlet. London.

Address delivered at the Anniversary Meeting on the 21st February, 1862, by Professor T. H. Huxley, Secretary. 8vo pamph. London. 1862.

Society of Arts, Manufactures, and Commerce.

Journal of the Society of Arts, and of the Institutions in Union. Vol. IX. No. 454 - 466; Vol. X. No. 481 - 521; Vol. XI. No. 522 - 544. 8vo. London. 1861 - 63.

Royal Horticultural Society.

Proceedings. Vol. I. No. 6 - 31; Vol. II. No. 1 - 12; Vol. III. No. 1 - 4. 8vo. London. 1859 - 62.

Journal. Vol. VII. Part 3; Vol. VIII. Part 4; Vol. IX. Part 3. 8vo. London. 1852 - 54.

List of Fellows (1861 - 62). 8vo pamph. London.

British Association for the Advancement of Science.

Report of the Thirty-first Meeting, held at Manchester in September, 1861. 8vo. London. 1862.

Royal Institution of Great Britain.

Notices of the Proceedings at the Meetings of the Members. Part 12. 1861 - 62. 8vo. London. 1862.

List of Members for 1861. 8vo. London. 1862.

Statistical Society of London.

Journal. Vol. XXV. Part 3. September, 1862. 8vo. London.

Tyneside Naturalists' Field-Club.

Transactions. Vol. V. Part 2, 3, 4. 8vo. Newcastle-upon-Tyne. 1862 - 63.

Radcliffe Trustees.

Astronomical and Meteorological Observations made at the Radcliffe Observatory, Oxford, in the Years 1859 and 1860. Vol. XX. Royal 8vo. Oxford. 1862.

Literary and Philosophical Society of Manchester.

Memoirs. Series 3. Vol. I. 8vo. London and Paris. 1862.

Proceedings. Vol. II. Sessions 1860 - 62. 8vo. Manchester. 1862.

Rules of the Society. 8vo pamph. Manchester. 1861.

Council of the City of Manchester.

Tenth Annual Report to the Council of the City of Manchester on the Working of the Public Free Libraries. October, 1862. 8vo pamph. Manchester. 1862.

Catalogue of the Chief Lending Library. 8vo pamph. Manchester. 1862.

Literary and Philosophical Society of Liverpool.

Proceedings. No. 16. 1861-62. 8vo. Liverpool. 1862.

Royal Dublin Society.

Journal. Vol. III. No. 20-25; Vol. IV. No. 26-28. 8vo. Dublin. 1861-63.

Royal Irish Academy.

Transactions. Vol. XXIV. Part 2. Science. 4to. Dublin. 1862.

Natural History Society of Montreal.

Canadian Naturalist and Geologist. Vol. VII. 8vo. Montreal. 1862.

Government of India.

Memoirs of the Geological Survey of India. Vol. IV. Part I. Royal 8vo. Calcutta. 1862.

Palæontologica Indica, being Figures and Descriptions of the Organic Remains procured during the Progress of the Geological Survey of India. I. 1; II. 1 and 2. 4to. Calcutta. 1861-62.

Annual Report of the Geological Survey of India and of the Museum of Geology for the Year 1861-62. 8vo pamph. Calcutta. 1862.

Lords Commissioners of the Admiralty, London.

The North-Atlantic Sea-Bed; comprising a Diary of the Voyage on board H. M. S. Bulldog, in 1860; and Observations on the Presence of Animal Life, and the Formation and Nature of Organic Deposits, at great Depths in the Ocean. By G. C. Wallich, M. D., F. L. S., F. G. S. Part 1. 4to. London. 1862.

Académie des Sciences de l'Institut Impériale de France.

Mémoires. Tom. XXVIII., XXX., XXXIII. 4to. Paris. 1860-61.

Mémoires Morales et Politiques. Vol. X. 4to. Paris. 1860.

Mémoires Mathématiques et Physiques. Vol. XVI., XVII. 4to. Paris. 1862.

Comptes Rendus. Vol. LIV., LV., LVI. No. 1-17. 4to. Paris. 1862-63. — Supplement. Vol. II. 1861.

Chevreul, M. E.

Exposé d'un moyen de définir et de nommer les Couleurs d'après une méthode précise et expérimentale avec l'application de ce moyen à la définition et à la dénomination des Couleurs d'un grand nombre de Corps naturels et de Produits artificiels. Atlas. 4to. Paris. 1861.

Société Géographique, Paris.

Bulletin. Ser. 5. Vol. II., III., IV. 8vo. Paris. 1861-62.

Société Impériale Zoologique d'Acclimatation.

Bulletin. Vol. IX., X. No. 1-4. 8vo. Paris. 1862-63.

Museum d'Histoire Naturelle, Paris.

Archives. Vol. X. Part 3, 4. 4to. Paris. 1861.

Académie Impériale des Sciences, etc., Rouen.

Precis Analytique des Travaux de l'Académie pendant l'Année. 1860-61; 1861-62. 2 vols. 8vo. Rouen. 1861-62.

Société Académique de Maine et Loire.

Vol. IX., X. 8vo. Angers. 1861.

Société Linnéenne de Normandie.

Bulletin. Vol. VI., VII. 1860-61; 1861-62. 8vo. Caen. 1862-63.

Mémoires. Vol. XII. 4to. Paris. 1862.

Académie Impériale des Sciences, etc., Caen.

Mémoires. 2 vols. 8vo. Caen. 1862-63.

Rapport sur le Concours ouvert le 26 Février 1858, lu dans une séance extraordinaire de l'Académie le 4 Décembre 1861 par M. Roulland (Prix le Sauvage). 8vo. Caen. 1862.

Académie Impériale des Sciences, etc., de Bordeaux.

Actes. Ser. 3. 24^e Année. 1862. 8vo. Paris. 1862.

Société des Sciences Naturelles de Strasbourg.

Mémoires. Vol. V. Part 1, 2. 4to. Strasbourg. 1862.

Société Impériale des Sciences Naturelles de Cherbourg.

Mémoires. Vol. VIII. 8vo. Paris and Cherbourg. 1861.

Académie Impériale des Sciences, etc., de Dijon.

Mémoires. Ser. 2. Vol. IX. 1861. 8vo. Dijon. 1862.

Société de Physique et d'Histoire Naturelle de Genève.

Mémoires. Vol. XVI. Part 2. 4to. Geneva. 1862.

Naturforschende Gesellschaft in Bern.

Mittheilungen. 1861. 8vo. Bern. 1861.

Naturforschende Gesellschaft in Basel.

Verhandlungen. Vol. III. Part 3. 8vo. Basel. 1862.

St. Gallische Naturwiss. Gesellschaft.

Bericht über die Thätigkeit. 1861-62. 8vo. St. Gallen. 1862.

Universitas Frid. Guil. Rhenana, Bonnæ.

Academical Dissertations and Indexes. Bonn. 1861.

Naturhistorische Verein der Preuss. Rheinlande und Westphalens.

Verhandlungen. Vol. XVIII., XIX. 8vo. Bonn. 1861-62.

Königl. Preussische Akademie der Wissenschaften, Berlin.

Abhandlungen. 1861. 4to. Berlin. 1862.

Monatsberichte. 1861. 8vo. Berlin. 1862.

Austrian Government.

Reise der Oesterreichischen Fregatte Novara um die Erde, in den Jahren 1857, 58, 59, unter den Befehlen des Commodore B. von Wallerstorf-Arbair. 3 vols. Royal 8vo. Vienna. 1861-62.

K. K. Akademie der Wissenschaften, Wien.

Denkschriften. Math.-Naturw. Classe. Vol. XX. 4to. Vienna. 1862.

Denkschriften. Philos.-Histor. Classe. Vol. XII. 4to. Vienna. 1862.

Sitzungsberichte. Philos.-Histor. Classe. Vol. XXXVIII. Part 1-3; Vol. XXXIX. Part 1-5; Vol. XL. Part 1-3.

Sitzungsberichte. Math.-Naturw. Classe. Vols. XLIV., XLV. 8vo. Vienna. 1862.

Register zu den Bänden 31 bis 42 der Sitzungsberichte der Math.-Naturw. Classe. 8vo pamph. Vienna. 1862.

Almanach der Akademie. Vol. XII. 16mo. Vienna. 1862.

K. K. Geologische Reichsanstalt, Wien.

Jahrbuch. Vol. XII. No. 2, 4. 8vo. Vienna. 1862.

London International Exhibition 1862. 8vo pamph. Vienna. 1862.

Die Fossilen Mollusken des Tertiär-Beckens von Wien. Von Dr. Moritz Hörnes. Vol. II. No. 3, 4. Bivalven. 4to. Vienna. 1862.

K. K. Zoologisch-Botanische Gesellschaft, Wien.

Verhandlungen. Vol. XI. 1861. 8vo. Vienna. 1861.

Nachträge zu Maly's Enumeratio Plantarum Phanerogamicarum Imperii Austriaci Universi, von August Neilreich. 8vo. Vienna. 1861.

Synopsis der im Rothen Meere vorkommenden Crustaceen von Dr. Cam. Heller (aus den Verhandlungen 1861). 8vo pamph. Vienna. 1861.

Königl. Sächsische Gesellschaft der Wissenschaften, Leipzig.

Abhandlungen. Math.-Phys. Classe. Vol. VI. pp. 51 – 498. Philol.-Histor. Classe. Vol. IV. pp. 111 – 344. Royal 8vo. Leipzig. 1861 – 62.

Berichte über die Verhandlungen. Math.-Phys. Classe Nos. 1, 2; Philol.-Histor. Classe, No. 2 – 4. 8vo. Leipzig. 1862.

Fürstl. Jablonowski'sche Gesellschaft, Leipzig.

Preisschriften gekrönt und herausgegeben von der Gesellschaft. Vol. IX. 1862. Vol. XL. 1863. Royal 8vo. Leipzig.

Königl. Gesellschaft der Wissenschaften zu Göttingen.

Abhandlungen. Vol. X. 4to. Göttingen. 1862.

Königl. Bayerische Akademie der Wissenschaften, München.

Abhandlungen. Math.-Phys. Classe. Vol. IX. Part 2; Philos.-Histor. Classe. Vol. IX. Part 1. 4to. Munich. 1862.

Sitzungsberichte. 1861. Vol. II. 1862. Vol. I. and II. Part 1. 8vo. Munich. 1861 – 62.

Annalen der königl. Sternwarte. Vol. XI. 8vo. Munich. 1862.

Verzeichniss der Mitglieder. 1862. 4to. Munich.

Zum Gedächtniss an Jean Baptiste Biot, gesprochen von Carl Friedrich Philipp von Martius. 4to pamph. Munich. 1862.

Ueber Parthenogenesis. Vortrag von Dr. C. Th. E. von Siebold. 8vo pamph. Munich. 1862.

Ueber die lange Dauer und die Entwicklung des Chinesischen Reiches. Rede zur Feier des Geburtsfestes Sr. Maj. Max. II. Von Dr. Joh. Heinrich Plath. 4to pamph. Munich. 1862.

Académie Royale des Sciences, &c. de Belgique, Bruxelles.

Mémoires. Vol. XXXII, XXXIII. 4to. Brussels. 1861.

Mémoires Couronnés, &c. Vol. XXX. 4to. Brussels. 1861.

Mémoires Couronnés. Coll. in 8vo. Vol. XI, XII. 8vo. Brussels. 1861 – 62.

Bulletin. Ser. 2. Vol. IX. – XII. 8vo. Brussels. 1861 – 62.

Annuaire. Vol. XXVII., XXVIII. 12mo. Brussels. 1861 – 62.

Alexanders Geesten van Jacob van Maerlant. Vol. I. Royal 8vo. Brussels. 1860.

Glossarium op Maerlants Rymbybel, Vervolgen Slot van Derde Deel. 8vo pamph. Brussels. 1861.

Observatoire Royale de Bruxelles.

Annales. Vol. XIII. 4to. Brussels. 1861.

Königl. Physikalisch-Oekonomische Gesellschaft zu Königsberg.

Schriften. Vol. II. 4to. Königsberg. 1862.

Königl. Böhmisches Gesellschaft der Wissenschaften zu Prag.

Sitzungsberichte. 1861. 8vo. Prague.

K. K. Sternwarte zu Prag.

Magnetische und Meteorologische Beobachtungen. Vol. XXII. 4to. Prague. 1862.

Naturforschende Gesellschaft zu Freiburg im Briesgau.

Berichte über die Verhandlungen. Vol. II. Part 4. 8vo. Freiburg. 1862.

*Kais. Leopoldinisch-Carolinisch Deutsche Akademie der Naturforscher.
(Academia Cæsarea Leopoldino-Carolina Germanica Naturæ
Curiosorum.)*

Nova Acta. Vol. XXVIII., XXIX. 4to. Jena. 1861-62.

Naturforschende Gesellschaft zu Halle.

Abhandlungen. Vol. VI. Part 2-4; Vol. VII. Part 1. 8vo. Halle. 1861-62.

Naturforschende Gesellschaft in Emden.

Jahresbericht. 1861. 8vo. Emden. 1862.

Kleine Schriften. No. IX. 4to. Emden. 1862.

Oberlausitzische Gesellschaft zu Görlitz.

Neues Lausitzisches Magazin. Vol. XXXIX. and XL. Part 1. 8vo. Görlitz. 1862.

Naturhistorische Verein in Augsburg.

Jahresbericht für 1862. 8vo. Augsburg. 1862.

Zoologisch-Mineralogische Verein in Regensburg.

Correspondenz-Blatt. Vol. XVI. 16mo. Ratisbon. 1862.

Königl. Universitäts-Sternwarte zu Königsberg.

Astronomische Beobachtungen. Part 34. Folio. Königsberg. 1862.

Declinationes Stellarum Fundamentalium Novæ ex Ultimis
III. Bessel Observationibus derivatæ. 4to pamph. Königsberg.
1859.

Entomologische Verein zu Stettin.

Entomologische Zeitung. Vol. XXIII. 8vo. Stettin. 1862.

Repertorium. 1840-62. 8vo. Stettin. 1862.

Verein für Erdkunde, Darmstadt.

Notizblatt. Ser. 3. Vol. I. No. 1, 2. 8vo. Darmstadt. 1862.

Aerztliche Verein in Frankfurt a. M.

Jahresbericht über das Medicinalwesen der Kranken-Anstalten der Freien Stadt Frankfurt. 1860. 8vo. Frankfort on the Main. 1863.

Zoologische Gesellschaft, Frankfurt a. M.

Zoologische Garten. Vol. III. 8vo. Frankfort on the Main. 1862.

Naturwissenschaftliche Gesellschaft zu Dresden.

Sitzungsberichte. 1861. 8vo. Dresden. 1862.

Verein für Naturkunde im Herzogthum Nassau.

Jahrbücher. XVI. Heft. 8vo. Wiesbaden. 1861.

Académie Royale des Sciences à Amsterdam.

Verhandelingen. Vol. IV. 4to. Amsterdam. 1862.

Verslagen en Mededeelingen Afdeeling Letterkunde. Vol. VI. —
Natuurkunde. Vol. XIII., XIV. 8vo. Amsterdam. 1862.

Jaarboek voor 1861. 8vo. Amsterdam. 1862.

Hollandsche Maatschappij der Metenschappen te Haarlem.

Natuurkundige Verhandelingen. Serie 2. Vol. XVI. 4to. Haarlem. 1862.

Natuurkundige Vereeniging in Nederlandsch Indie, Batavia.

Natuurkundig Tijdschrift. Vol. XIX. Serie 4. Vol. V.; Vol. XXIII. Serie 4; Vol. III. Part 4, 6; Vol. XXIV. Serie 5. Vol. IV.; Part 1-4. Batavia. 8vo. 1859, 1861-62.

Acta Societatis Scientiarum Indo-Neerlandicae. Vol. V., VI. 4to. Batavia. 1859.

Bataviaasch Genootschap van Kunsten en Wetenschappen, Batavia.

Tijdschrift voor Indische Taal-, Land- en Volkenkunde. Vol. VII. - X. 8vo. Batavia. 1857-60.

Verhandelingen. Vol. XXVII., XXVIII. 4to. Batavia. 1860.

Académie Impériale des Sciences de St. Petersburg.

Bulletin. Vol. IV. No. 3-6. 4to. St. Petersburg. 1861.

Mémoires. Serie 7. Vol. III. Vol. IV. No. 1-4. 4to. St. Petersburg. 1861.

Administration of Mines of Russia.

Annales de l'Observatoire Physique Central de Russie. 1859.

No. 1, 2. 4to. St. Petersburg. 1862.

Kaiserl. Gesellschaft für die Gesamm. Mineralogie zu St. Petersburg.

Verhandlungen. 1862. 8vo. St. Petersburg. 1862.

Société Impériale des Naturalistes de Moscou.

Bulletin. 1861. No. 1 – 4. 8vo. Moscow. 1861.

Société Royale des Sciences à Upsal.

Nova Acta. Serie 3. Vol. IV. Part 1. 4to. Upsal. 1862.

Upsala Universitets Årsskrift. 1861. Medecin. Theolog. Mathematik, &c. 5 pamph. 8vo. Upsal. 1861.

Kongelige Norske Frederiks Universitet, Christiania.

Aarsberetning fer 1860. 16mo. Christiania. 1862.

Forhandling i Videnskabs-Selskabet i Christiania. 1858 – 61. 4 vols. 8vo. Christiania. 1859 – 62.

Norsk Forfatter-Lexicon 1814 – 1856 af Jens Kraft. Efter Forfatterens Dod. . . af Christian C. A. Lange. Part 1 – 5. 8vo. Christiania. 1857 – 60.

Generalberetning fra Gaustad Sindssygeasyl for 1861. Ved Ole Sandberg, Direktor. 4to pamph. Christiania. 1861.

Beretning om Sunhedstilstanden og Medicinalforholdene i Norge i 1857 – 1860. 4 pamph. 4to. Christiania. 1860 – 61.

Oversigt af Norges Echinodermer ved Dr. Michael Sars. 8vo vol. Christiania. 1861.

Recherches sur la Syphilis appuyées de Tableaux de Statistique tirés des Archives des Hopitaux de Christiania par W. Boeck. 4to vol. Christiania. 1862.

Die Culturpflanzen Norwegens beobachtet von Dr. F. C. Schübler, . . . mit einem Anhang über die Altnorwegische Landwirthschaft, mit einem Vorwort von Chr. Boeck. Vol. 4to. Christiania. 1862.

Academia Real das Sciencias de Lisboa.

Memorias. Classe de Sc. Math., Phys. e Naturaes. N. S. Vol. I. Part 1; Vol. II. Part 1, 2. Classe de Sc. Moraes. Polit. e Bellas Lettras. N. S. Vol. I. Part 1, 2; Vol. II. Part 1. 4to. Lisbon. 1854 – 61.

Portugaliae Monumenta Historica Scriptores. Vol. I. Part 2, 3. Folio. Lisbon. 1860 – 61.

Quadro Elementar das Relacoes Politicas e Diplomaticas de Portugal, com as diversas Potencias do Mundo desde o Principio do XVI. Seculo da Monarcha Portugueza ate aos nossos Dias colligido e coordenado pelo Visconde de Santarem e Continuado e dirigido pelo Socio da Acad. . . Luiz Augusto Rebello da Silva. Vol. XVIII. 8vo. Lisbon. 1860.

Lendas da India por Gaspar Correa publicadas de Orden da

Classe da Sc. Moraes, etc., e sob Direcao de Rodrigo Jose de Lima Felner. Vol. II. Part 2. 4to. Lisbon. 1860-61.

Real Academia de Ciencias de Madrid.

Memorias. Vol. III. Serie 2. Ciencias Fisicas. Vol. I. Part 2. Vol. IV. Serie 3. Ciencias Naturales. Vol. II. Part 3; Vol. V. Cienc. Nat. Vol. III. Part 1. 4to. Madrid. 1859-61.

Resumen de las Actas de la Academia en el Año Academico. 1853-59. 8vo. 6 pamph. Madrid. 1857-60.

Programas de Premios 1859-62. 4to. 4 pamph. Madrid.

Observatorio de Marina de S. Fernando, Cadiz.

Almanaque Nautico para el Año 1863-64. Royal 8vo. Cadiz. 1861-62.

G. Poulett Scrope.

Mémoire sur le Mode de Formation des Cones Volcaniques et des Cratères. Traduit de l'Anglais par Endymion Pieraggi. 8vo pamph. Paris. 1860.

Hon. Charles Sumner.

Indemnity for the Past and Security for the Future. Speech of Hon. Charles Sumner of Massachusetts, on his Bill for the Confiscation of Property and the Liberation of Slaves belonging to Rebels. In the Senate of the United States, May 19, 1862. 8vo pamph. Washington. 1862.

Speech of Hon. Charles Sumner of Massachusetts, on the House Bills for the Confiscation of Property and the Liberation of Slaves belonging to Rebels, delivered in the Senate of the United States, June 27, 1862. 8vo pamph. Washington. 1862.

Speech of Hon. Charles Sumner on the Bill to authorize the appointment of Diplomatic Representatives to the Republics of Hayti and Liberia. In the Senate of the United States, April 23 and 24, 1862. 8vo pamph. Washington. 1862.

Speech of Hon. Charles Sumner of Massachusetts, on the Bill to authorize the President, in all Domestic or Foreign Wars, to issue Letters of Marque and Reprisal. In the Senate of the United States, Feb. 17, 1863. 8vo pamph. Washington. 1863.

Immediate Emancipation a War Measure! Speech of Hon. Charles Sumner of Massachusetts, on the Bill providing for Emancipation in Missouri. In the Senate of the United States, Feb. 12, 1863. 8vo pamph. Washington. 1863.

Protection and Freedom in Arizona. Speech of Hon. J. M. Ash-

ley of Ohio, delivered in the House of Representatives, May 8, 1862. 8vo pamph. Washington. 1862.

Report of the Joint Committee on the Conduct of the Present War (B. F. Wade, Chairman). 8vo pamph. Washington. 1862.

Report of the Superintendent of the Coast Survey, showing the Progress of the Survey during the Year 1860. 4to vol. Washington. 1861. [Ex. Doc.]

Report of the Commissioner of the General Land Office, accompanying the Annual Report of the Secretary of the Interior for the Year 1860. 8vo vol. Washington. 1860.

Preliminary Report on the Eighth Census, 1860. By Joseph C. G. Kennedy, Superintendent. 8vo vol. Washington. 1862. [Pub. Doc.]

Francis Alger.

A Course of Instruction in Ordnance and Gunnery ; compiled for the Use of the Cadets of the United States Military Academy. By Captain J. G. Benton, Ordnance Department. Second Edition. Revised and Enlarged. Royal 8vo vol. New York. 1862.

Henry W. Williams, M. D.

A Practical Guide to the Study of Diseases of the Eye. 12mo vol. Boston. 1862.

Spectacles : their Uses and Abuses in long and short sightedness ; and the Pathological Conditions resulting from their irrational Employment. By J. Sichel, M. D. Translated from the French, by permission of the Author, by Henry W. Williams, M. D. 12mo vol. Boston. 1850.

Dr. E. Regel.

Catalogus Plantarum quæ in Horto Aksakoviano coluntur. 8vo vol. St. Petersburg. 1860.

Tentamen Floræ Ussuriensis, oder Versuch einer Flora des Ussuri-Gebietes. [Mem. Acad. Imp. Sci. de St. Petersbourg. Ser. 7. Vol. IV. No. 4.] 4to vol. St. Petersburg. 1861.

Uebersicht der Arten der Gattung Thaliotrum, welche im Russischen Reiche und den angraenzenden Laendern wachsen. 8vo pamph. Moscow. 1861.

Nachträge zur Flora der Gebiete des Russischen Reichs östlich vom Altai bis Kamtschatka und Sitka nach den von G. Radde, Stuebendorff, Sensinoff, Rieder und andern gessammelten Pflanzen. 8vo pamph. Moscow. 1861.

Flora der Gebiete des Russischen Reichs Oestlich vom Altai bis nach Kamtschatka und dem Russischen Nordamerika. Vol. I. Part II. 8vo. Moscow. 1862.

Edward Jarvis, M. D.

Mechanical and other Employments for Patients in the British Lunatic Asylums. By Edward Jarvis, M. D., Dorchester, Mass. [Read before the Association of Medical Superintendents of American Institutions for the Insane.] 8vo pamph.

The Sanitary Condition of the Army of the United States. By Edward Jarvis, M. D. [From the Atlantic Monthly for October, 1862.] 8vo pamph. Boston. 1862.

Proceedings on the occasion of Opening the New Pennsylvania Hospital for the Insane at Philadelphia. 8vo pamph. Philadelphia. 1859.

Memorial on Decimal Weights. Presented to the Right Hon. Benjamin D'Israeli, M. P., Chancellor of Her Majesty's Exchequer, March 19, 1859. 8vo pamph. London. 1859.

C. H. F. Peters.

Report of the Regents of the University of the State of New York on the Longitudes of the Dudley Observatory, the Hamilton College Observatory, the City of Buffalo, and the City of Syracuse. 8vo pamph. Albany. 1862.

Jules Marcou.

Letter to Joachim Barrande on the Taconic Rocks of Vermont and Canada. 8vo pamph. Cambridge. 1861.

The Taconic and Lower Silurian Rocks of Vermont and Canada. 8vo pamph. Boston. 1862.

Observations on the Terms "Peneen," "Permien," and "Dyas." 8vo pamph. Boston. 1862.

Défense des Colonies. Part I. and II. Par Joachim Barrande. 8vo. 2 pamph. Prague and Paris. 1861, 1862.

Thomas Macfarlane.

On the Primitive Formations in Norway and in Canada, and their Mineral Wealth. 8vo pamph. 1862.

J. W. Dawson.

On the Flora of the Devonian Period in Northeastern America. 8vo pamph. London. 1862.

On the Footprints of *Limulus* as compared with the *Protichnites* of the Potsdam Sandstone. 8vo pamph.

A. Agassiz.

The Mode of Development of the Marginal Tentacles of the Free Medusæ of some Hydroids. 8vo pamph. Boston. 1862.

L. Agassiz.

Annual Report of the Trustees of the Museum of Comparative Zoölogy, together with the Report of the Director. 1862. 8vo pamph. Boston. 1863.

S. Kneeland, M. D.

History of North Carolina: with Maps and Illustrations. By Francis L. Hawks, D.D., LL. D. Vol. II. Embracing the Period of the Proprietary Government, from 1663 to 1729. 8vo. Fayetteville, North Carolina. 1858.

Historical Sketches of North Carolina, from 1584 to 1851. Compiled from Original Records, Official Documents, and Traditional Statements. . . . By John H. Wheeler. Vol. I. 8vo. Philadelphia. 1851.

Instruction for Field Artillery, extracted from Gilham's Manual for Volunteers and Militia. 16mo pamph. Richmond, Va. 1861.

J. D. Whitney.

Report of a Geological Survey of the Upper Mississippi Lead Region. 4to vol. Albany, N. Y. 1862.

John Bacon, M. D.

Micrographic Dictionary; a Guide to the Examination and Investigation of the Structure and Nature of Microscopic Objects. By J. W. Griffith, M. D., F. L. S., etc., and Arthur Henfrey, F. R. S., F. L. S. 8vo. London. 1856.

Felix Flugel.

Die Absorption des Lichtes in isotropen Mitteln. Von Dr. Adolph Wüllner. 8vo pamph. Marburg. 1862.

A. Quetelet.

Annuaire de l'Observatoire Royal de Bruxelles. Par A. Quetelet. 1861 - 62. 2 vol. 16mo. Brussels. 1860 - 61.

Observations des Phénomènes Périodiques. 1859 - 60. 4to. 2 pamph. Brussels.

Sur le Congrès International de Statistique tenu à Londres le 16 Juillet 1860 et les cinq Jours suivants; par Ad. Quetelet. 4to pamph. Brussels.

De la Nécessité d'un Système General d'Observations Nautiques et Météorologiques. Lettre de M. Maury, Directeur de l'Obser-

vatoire de Washington à M. Ad. Quetelet. 16mo pamph. Brussels.

Dr. Gustav Zeuner.

Ueber das Wanken der Locomotiven. 4to pamph. Zurich. 1861.

Dr. Rudolf Wolf.

Ueber den mittlern jährlichen Verlauf des Sternschnuppenphänomenes nach Beobachtungen in den Jahren 1851 bis 1859. 12mo pamph. Zurich.

B. A. Gould.

Standard Mean Right-Ascensions of Circumpolar and Time Stars, prepared for the Use of the U. S. Coast Survey. A. D. Bache, Superintendent. 4to pamph. Washington. 1862.

Isaac Lea.

Observations on the Genus Unio. Vol. IX. 4to. Philadelphia.

Description of a New Genus (Trypanostroma) of the Family Melanidæ. Description of ten new species of Unionidæ of the United States. 8vo pamph. Philadelphia. 1862.

Achille De Zigno.

Sulla Flora Fossile dell' Oolite. 4to pamph. Venice. 1856.

Flora Fossilis Formationis Oolithicæ. Le Piantе Fossili dell' Oolite descritte ed illustrate. Part I. and II. 4to. 2 pamph. Padua. 1856 - 58.

Della Geologia e suoi Progressi prima del Secolo XIX. 16mo pamph. Padua. 1853.

Sopra un Nuovo Genere di Felce Fossile. 16mo pamph. Venice. 1861.

Della Alghe e delle Calamarie dei Terreni Oolitici. 16mo pamph. Padua. 1859.

Nouvelles Observations sur les Terrains Crétacés des Alpes Vénitiennes. 16mo pamph. Padua. 1850.

Prospetto dei Terreni Sedimentarii del Veneto. 16mo pamph. Venice. 1858.

Del Terreno Carbonifero delle Alpi Veneti. 16mo pamph. Venice. 1858.

Sulla Costituzione Geologica dei Monti Euganei. 16mo pamph. Padua. 1861.

Intorno ai Cenni del Professore Tomaso Antonio Catullo sopra il Sistema Cretaceo delle Alpi Veneti. 16mo pamph. Padua. 1846.

Sulla Paleontologia della Sardegna del Cav. Gius. Meneghini. Relazione di Achille De Zigno. 16mo pamph. Venice. 1858.

James D. Dana.

Manual of Geology : treating of the Principles of the Science with Special Reference to American Geological History, for the Use of Colleges, Academies, and Schools of Science. 8vo vol. Philadelphia. 1863.

Rev. Charles Brooks.

Society for the Relief of Aged and Destitute Clergymen. Extracts from Records relating to its History and Objects (not published). 8vo pamph. Boston. 1862.

Hon. John P. Hale.

Catalogue of Additions made to the Library of Congress from Dec. 1, 1861, to Dec. 1, 1862. 8vo vol. Washington. 1862.

Albert Kölliker.

Ueber das Ende der Wirbelsäule der Ganoiden und einigen Telostier. 4to vol. Leipsic. 1860.

Ueber die Beziehungen der Chorda dorsalis zur Bildung der Wirbel der Selachier und einiger andern Fische. 8vo pamph. Wurzburg. 1860.

Ueber den Bau der Sägefische. 8vo pamph. Wurzburg.

Ueber den Antheil der Chordascheide an der Bildung des Schädelgrundes der Squalidæ. 8vo pamph. Wurzburg.

Ueber die Entwicklung des Geruchsorganes beim Menschen und beim Hünchne. 8vo pamph. Wurzburg. 1860.

Der Embryonale Schneckenkanal und seine Beziehungen zu den Theilen der fertigen Cochlea. Eine kurze Mittheilung. 8vo pamph. Wurzburg. 1861.

Ueber die Grosse Verbreitung der "perforating fibres" von Sharkey. 8vo pamph. Wurzburg. 1860.

E. B. Elliott.

Preliminary Report of the Mortality and Sickness of the Volunteer Forces of the U. S. Government during the present War. By E. B. Elliott. (Sanitary Commission, No. 46.) 8vo pamph. New York. 1862.

Hon. Charles G. Loring.

Correspondence on the Present Relations between Great Britain and the United States of America. 8vo vol. Boston. 1862.

Professor William D. Whitney.

The Atharva-Veda Prâtîcākhyā, or Cāunakīyā Caturādhyāyikā : Text, Translation, and Notes. By William D. Whitney, Professor

of Sanscrit in Yale College. (From Jour. Amer. Oriental Society, Vol. VII. 1862.) 8vo. New Haven. 1862.

Editors of American Journal of Science and Arts.

Recent Researches relating to Nebulæ. By Prof. A. Gautier. (From Am. Jour. of Science and Arts, Vol. XXXV. Jan., 1863.) 8vo pamph. New Haven. 1863.

Elias Fries.

Epicrisis Hieraciorum. 8vo vol. Upsal. 1862.

Henri de Saussure.

Coup d'Œil sur l'Hydrologie du Mexique principalement de la Partie Orientale accompagné de quelques Observations sur la Nature Physique de ce Pays. 1st Part. Vol. 8vo. Geneva. 1862.

Orthoptera Nova Americana. Diagnoses Præliminares. Ser. III. [Extr. de la Rev. et Mag. de Zool., Avril, 1862.] 8vo pamph. Paris. 1862.

Etudes sur quelques Orthoptères du Musée de Genève. Nouveaux ou imparfaitement connus. [Extr. des Ann. de la Soc. Entomol. de France, Ser. IV. Vol. I. 1862.] 8vo pamph. Paris. 1861.

Sur Divers Vespides Asiatiques et Africains du Musée de Leyden. 8vo pamph.

G. Giuseppe Bianconi.

Del Colore prodotto per l'Attrito fra Fluidi e Solidi in Rapporto colle Sorgenti Termali e cogli Aeroliti. 8vo pamph. Bologna. 1862.

Cenni Storici sugli Studi Palæontologici e Geologici in Bologna e Catalogo ragionato della Collezione Geognostica dell'Apennino Bolognese. 8vo pamph. Bologna. 1862.

Henry T. Parker.

Freedom or Slavery in the United States, being Facts and Testimonies for the Consideration of the British People. By Peter Sinclair. 2d ed. 8vo vol. London.

J. L. Sibley.

Report of the Committee of the Overseers of Harvard College appointed to visit the Library for the Year 1862. Submitted Feb. 19, 1863. 8vo pamph. Boston. 1863.

Hon. Henry Wilson.

Report of the Committee on Military Affairs and the Militia, to whom was referred the Petition of Dr. William T. G. Morton, asking

Compensation for the Discovery and Gift to his Country and Mankind of the Application of Ethereal Vapor, as a safe and practical Anæsthesia, or Pain-subduing Agent. 8vo pamph. Washington. 1863. [Pub. Doc.]

Charles S. Storrow.

Report of the Commissioners upon the Troy and Greenfield Railroad and Hoosac Tunnel, Feb. 28, 1863. 8vo vol. Boston. 1863.

Charles Folsom.

An Essay on the Senses of Smell and Taste; to which was awarded the Prize of the Boylston Medical Society in 1863. By Norton Folsom. 8vo pamph. Boston. 1863.

St. Louis Mercantile Library Association.

Seventeenth Annual Report of the Board of Directors of the Association. 8vo pamph. St. Louis. 1863.

Young Men's Mercantile Library Association of Cincinnati.

Twenty-eighth Annual Report of the Board of Directors. 8vo pamph. Cincinnati. 1863.

Commonwealth of Massachusetts.

Report of the Joint Standing Committee on Federal Relations, to whom was referred so much of the Governor's Address as relates to the Military Defences of the State, the Petition of B. N. Bullock in regard to an invention for iron armor for vessels, and the Order of the Senate relative to taking measures for calling out the mechanical and inventive talent of the Commonwealth. 8vo pamph. Boston. 1862. [Senate Doc. No. 177.]

Five hundred and twenty-fourth Meeting.

August 12, 1863. — STATED MEETING.

The VICE-PRESIDENT in the chair.

The Corresponding Secretary read a letter from Messrs. Siliman and Dana, presenting the American Journal of Science and Arts to the Academy for the current year.

Dr. Charles T. Jackson exhibited a mass of meteoric iron, weighing nearly eleven pounds, which was sent to him by Major John B. Hoffman, United States Agent to the Ponca tribe of Indians.

This specimen was detached from a mass weighing one hundred pounds. It was found on the surface of the earth in the Dacotah Indian country, ninety miles from any road or dwelling. Owing to a natural fissure in the mass, and its columnar structure, it was found practicable to divide it by aid of a sledge-hammer. It was supposed in Dacotah that this metal was some alloy of silver, on account of the remarkable whiteness of some portions of the mass, and it was sent to Boston to be assayed for silver. The specimen was at once recognized as meteoric iron, and a subsequent analysis confirmed that conjecture. Native metallic iron in large masses has not yet been recognized on this planet, excepting when it is of meteoric origin. Masses which have been seen to fall from the heavens have been found to contain an alloy of iron, nickel, tin, chrome, phosphorus, and occasionally a little sulphur and iron have also been detected in them.

Chemical analysis of the Dacotah meteorite gave the following results:—

Specific gravity 7.952.

Metallic iron, whiter than artificial iron; has in some places a hardened crust on the surface, but internally files quite soft.

Analysis.	No. 1.	No. 2.
Metallic Iron,	91.735	91.735
“ Nickel,	6.532	7.080
“ Tin,	0.063	0.063
Phosphorus,	0.010	0.010
Cobalt, }	traces.	
Chrome, }		
	98.340	98.888

No chlorine, sulphur, or copper was discovered in this meteorite.

Dr. Jackson also exhibited some beautiful and perfect crystals of green felspar, or Amazonian stone, from the granite quarries of Rockport, Massachusetts.

This mineral was first discovered at Rockport by Rev. S. Barden of that town. He subsequently discovered purple fluor-spar, small crystals of zircon, and very large and handsome crystals of smoky quartz, equal in beauty to those found near Mount Saint Gothard in Switzerland. Recently, Rhodonite or red bi-silicate of manganese and Fergussonite, a compound of oxides of tantalum, yttria, and cerium, have been discovered by Mr. Barden, and determined by the analyses of Dr.

Jackson. Mr. Alger has also recognized some minute crystals of topaz on the green felspar. It appears, therefore, that the granite rocks of Rockport are far from being barren in minerals of scientific value.

A report from the Rumford Committee was presented, and, there being no quorum for the transaction of business, was referred to an adjourned meeting.

Five hundred and twenty-fifth Meeting.

September 8, 1863. — ADJOURNED STATED MEETING.

The PRESIDENT in the chair.

The President read a letter from Professor Hitchcock, accompanying a memoir entitled "Supplement to the Ichnology of New England." Also a note from Professor Eliot, resigning his place as a member of the Rumford Committee.

Professor Lovering called up the recommendations of the Rumford Committee, which were read at the previous meeting and referred to this meeting for the action of the Academy. On the motion of Dr. Beck, it was

Voted, That the sum of three hundred dollars be paid from the income of the Rumford fund to Mr. O. N. Rood, to be used by him in making investigations on the subject of the physical relations of the iodized plate to light; — the results of these investigations to be communicated to the Rumford Committee, and to be offered by them for publication in the Memoirs of the American Academy of Arts and Sciences.

Professor Bond gave an account of the construction of achromatic object lenses by Dr. Steinheil of Munich, according to the method of Gauss; this being the first successful attempt at working lenses in the form proposed by Gauss for the correction of chromatic aberration, independently of spherical aberration. Lenses thus constructed have the advantage of combining large apertures with short focal lengths, and thus require only short telescope-tubes, which are least liable to errors from flexure. The thickness of the glass needed for producing lenses of the requisite curvatures is one of the chief difficulties in constructing this species of achromatic lens.

Professor Peirce presented an account of a ternary system of arithmetical notation, consisting of the three characters 1, 0, and $\bar{1}$ (*minus one* being written in the manner of the negative characteristics of logarithms). This system has the same property as the binary system discussed by Leibnitz, namely, that of reducing the processes of multiplication and division to series of additions and subtractions. It would require to express the same values about twice as many figures as the decimal system; but, as these are the simple characters 1, 0, $\bar{1}$, they would occupy but little more room on the printed page.

Professor Peirce considered the probable consequences of an adoption of such a system for the uses of life, and thought that, if this notation could ever have come into use, it would have been converted into a system of nine figures by the union in pairs of the fundamental characters.

Five hundred and twenty-sixth Meeting.

October 13, 1863. — MONTHLY MEETING.

The PRESIDENT in the chair.

Professor Bond presented a communication "On the new form of the Achromatic Object-Glass recently introduced by Steinheil."

In June, 1860, Professor Steinheil communicated to the Royal Academy of Sciences at Munich* a notice of an object-glass of thirty-six lines aperture, executed at his optical establishment according to the system of curves proposed by Gauss in an article published in the *Zeitschrift für Astronomie* of Lindenau and Bohnenberger, in 1817.†

This telescope, and subsequently another‡ of similar form, but larger, have been carefully tested, and, in the opinion of competent

* Sitzungsberichte der königl. bayer. Akademie der Wissenschaften zu München, 1860, II. 160.

† Lindenau und Bohnenberger, *Zeitschrift für Astronomie*, Nov., Dec. 1817, IV. 345.

‡ Sitzungsberichte, 1860, V. 662.

judges, they have exhibited a more complete achromatism, and in other respects more perfect definition, than was to be found with object-glasses of the ordinary form, of equal dimensions.

Some part of this superiority may be attributable to the manner of mounting the lenses, which admits of readily changing their relative positions so as to effect the best adjustment by actual trial; a provision undoubtedly of considerable value, but perhaps equally applicable in the old system, if a slight separation of the inner surfaces of the crown and flint lenses were made one of the conditions for determining the curves. By this means, as Steinheil has remarked, we may not only diminish outstanding errors in the object-glass, but also, to some extent, the aberrations of the eyepiece, and even defects in the eye itself. There seems, however, to be no reason to doubt that these object-glasses owe their excellence mainly to the improved theory of their curves.

Among other advantages, the new combination admits of larger angles of aperture than would otherwise be practicable, without compromising the clearness of the definition. It is here, in fact, that the value of the improvement is best illustrated. Any shortening of the focal length accomplished without sacrificing illuminating power, or defining qualities, is a substantial gain in more than one direction. It reduces the telescope to a more manageable size, which, in one of the larger class, is a matter of the first importance, for not only is the size of the dome and building required to protect it, and, in general, the cost of all the accessory apparatus necessary for its efficiency, largely diminished by a reduction in the length of the focus, but the facility of using it depends also very much on the same condition. Again, by shortening the tube, we apply the only really effectual means of reducing the flexure,—the most intractable of all sources of error in meridian instruments.

Hitherto, in the practice of the best opticians, the apertures of the largest object-glasses have not exceeded $\frac{1}{15}$ of the focal length, which is the proportion in Mr. Clark's 18.5-inch lens. With those of moderate size the ratio of $\frac{1}{13}$ to $\frac{1}{14}$ has been successfully employed. Of such, the object-glasses of the vertical circle and prime vertical instrument at Poulkova, of 6-inch aperture, are examples of remarkable excellence. At present, however, Messrs. Merz are prepared to extend the ratio of $\frac{1}{14}$ even to lenses of $19\frac{1}{4}$ inches (English) aperture; a gain in the surface exposed to the light for the same focal length, of

nearly seventy per cent. Steinheil has stated, that, with the Gaussian objectives, ratios of the aperture to the focal length as large as $\frac{1}{10}$ can be used for the largest refractors.* It must be remembered, that, owing to the strong curvature of the surfaces, the light has to traverse a greater thickness of the glass, and must experience more than ordinary loss from extinction. Perhaps, also, there will be a sensibly greater loss from reflection, from the greater inclination of the incident ray to the surface near the margin. The gain in area will, therefore, not represent precisely the increase in illuminating power.

There are two other objections to the new construction which may be thought in some measure to counterbalance its special advantages: one of these is the much greater depth of its curves, suggesting, perhaps without sufficient foundation, practical difficulties of workmanship. That they have been actually overcome in lenses of moderate size is certainly the best reason for anticipating success when the trial is made on a larger scale. It is further evident, from the peculiar form of the lenses, each of which is a meniscus, that, if they are worked out of flat discs, as usual, greater thickness of material will be required. This would increase the difficulty, already so great, of procuring suitable glass. It is possible that the material could be accommodated nearly to the ultimate form of the lenses, just as, in the present process of manufacture, an irregular mass is moulded into a flat disc, approximating to the shape required. It does not appear that either of these obstacles would long remain in the way of the general adoption of the new system, if its advantages were distinctly recognized, and sufficient inducements were offered to artists and to the manufacturers of optical glass to turn their efforts in this direction.

The contrast presented in the character of the curves in the two combinations, which is so decided that the eye at once distinguishes between them without any occasion for measurement or exact comparison, is very remarkable; for if the superiority of Gauss's combination be admitted, it shows that the practice of opticians has been confined to a region altogether removed from that in which the best system is to be found. In this they have only adopted the recommendations of the many eminent mathematicians who have treated of the theory of the achromatic object-glass.

The question proposed in this theory is to ascertain that form and

* Sitzungsberichte der königl. bayer. Akad. der Wiss., 1860, V. 663.

disposition of the surfaces of two or more lenses, composed of materials of different dispersive powers, which shall most effectually destroy the aberrations of color and of figure. The problem, in the form in which it has been practically presented, is indeterminate, so that, for instance, in the case of lenses of crown and flint glass, "For every lens of crown-glass of positive focus, whatever the radii of its surfaces may be, a lens of flint-glass can be computed which will form, when united with it, an achromatic object-glass," — achromatic, that is to say, in the limited sense in which the term is commonly accepted.

This allows, of course, of a great range in the choice of curves, and a variety of conditions have been proposed for determining the selection. In one respect only has there been a general consent of authorities. The front lens has always been convex on both surfaces. But it would seem that in this particular the direction given to the investigation has not been fortunate. It is at least an oversight, that the relative importance of the two principal sources of indistinctness has not been kept prominently in view. For while it is admitted that the chromatic dispersion is the chief source of indistinctness, the arbitrary condition has not been determined with special reference to this circumstance.

This omission has been supplied by Gauss, who has given attention mainly to the more complete elimination of the aberration of color, while, at the same time, his expectations that this could be done without sensibly increasing the spherical aberration, have been fully realized in the performance of the new object-glasses. Indeed, it deserves notice that the resulting curves bear a considerable resemblance to one of the systems which has been designed with express reference to the correction of the spherical aberration. Allusion is here made to the forms deduced by Herschel* for the elimination of the spherical aberration of diverging, as well as parallel rays. From the comparisons subjoined, it will be seen that one of the solutions satisfying his equations approximates nearly to Gauss's system, while the other approaches to a form employed by Fraunhofer. So far, therefore, as this holds good, each fulfils the conditions proposed in Herschel's theory.

As Gauss has published neither the mathematical investigation of the subject, nor even the final equations from which his curves were computed, we have not the means of deciding with entire certainty, whether

* Phil. Trans., 1821, p. 258.

the resemblance referred to is merely accidental, or whether it expresses an affinity involved in the nature of the problem. But the latter seems the more probable explanation. The numerical values of the radii in his system, computed for a special case,* are here transcribed from his original memoir, after reducing them to a focal length, for the two lenses combined, of twenty-one French feet, for the sake of comparison with the large Munich refractors.

I. Gauss's Curves.

1st surface of the crown lens, convex, radius,	$= + 2.535$	ft.
2d " " " concave, "	$= - 7.521$	
1st " " flint lens, convex, "	$= + 3.123$	
2d " " " concave, "	$= - 2.084$	†
Compound focus,	$= 21.00$	

In No. 1289 of the *Astronomische Nachrichten* Oudemans has given the following measurements of an object-glass made by Fraunhofer for the Equatorial of the Observatory at Utrecht. The numbers have been reduced to the same unit as before, assuming the focal length from *Astr. Nach.* 1281.

II. Fraunhofer's Curves.

1st surface of the crown lens, convex, radius,	$= + 14.157$	ft.
2d " " " " "	$= + 5.635$	
1st " " flint lens, concave, "	$= - 5.775$	
2d " " " convex, "	$= + 25.945$	
Compound focus,	$= 21.00$	

Another of his object-glasses, probably computed from a similar formula, but for glass of slightly different refractive and dispersive powers, has values of the radii as follows ‡:—

III. Fraunhofer's Curves.

1st surface of the crown lens, convex, radius,	$= + 15.430$	ft.
2d " " " " "	$= + 6.144$	
1st " " flint lens, concave, "	$= - 6.262$	
2d " " " convex, "	$= + 22.461$	
Compound focus,	$= 21.00$	

* Zeitschrift für Astron., IV. 350.

† This number has been corrected to accord with the *erratum* noticed at the end of the volume cited.

‡ Zeitschrift für Astron., IV. 352.

These numbers we will now compare with the two solutions of Herschel's equations, using the notation l , r and r' , to denote the reciprocals of the compound focal length and of the radii of the front surfaces of the two lenses. The substitution of the values of the indices of refraction and of the dispersive powers which have been used by Gauss for computing the system I. gives the relations * :—

$$0 = 2.3200 r^2 - 21.31 lr + 59.57 l^2 + 3.5792 lr' - 1.4233 r'^2$$

$$0 = 6.6400 r - 24.95 l - 4.1119 r'$$

From which we have

$$0 = -1.3917 r^2 + 12.37 lr - 14.56 l^2$$

with the roots

$$\frac{r}{l} = 7.4922, \quad \text{and} \quad \frac{r}{l} = 1.3964,$$

which afford the subjoined two sets of values.

IV. *Herschel's Curves.*

$$\frac{r}{l} = 7.4922$$

1st surface of the crown lens, convex, radius,	= +	2.803	ft.
2d " " " concave, "	= -	9.525	
1st " " flint lens, convex, "	= +	3.482	
2d " " " concave, "	= -	2.361	
Compound focus, "	=	21.00	

$$\text{V. } \frac{r}{l} = 1.3964$$

1st surface of the crown lens, convex, radius,	= +	15.038	ft.
2d " " " convex, "	= +	5.397	
1st " " flint lens, concave, "	= -	5.507	
2d " " " convex, "	= +	22.135	
Compound focus,	=	21.00	

With these radii the figures in the accompanying Plate have been constructed, representing sections of the different object-glasses, each having a focal length of two feet, and an aperture of nearly four

* In the equation (2) Phil. Trans. 1821, p. 258, the coefficient of ω^2 has been corrected from $\frac{2\mu' + 1}{\mu' - 1}$ to $\frac{3\mu' + 1}{\mu' - 1}$. Vide Article on Light, Encyc. Met., p. 424.

inches. The ratio of the aperture to the focal length has been taken larger than can be adopted in practice, in order to exaggerate the amount of curvature. It will be seen that the curves in the systems of Gauss and Fraunhofer may be nearly represented by the two solutions of Herschel's equations.*

It follows that Gauss's form, originally designed to secure a more complete elimination of the chromatic dispersion, must be also rather favorable than otherwise as regards the correction of the aberration of figures. It may be remarked, further, that his investigation, neglecting the thickness and distance of the lenses, leads to an equation of the fourth degree, which has no solution corresponding to V., nor to the above values of the radii used by Fraunhofer. On the other hand, if the curves in III. and V. have been derived from substantially the same theory, which seems a probable inference, it is scarcely possible that Fraunhofer should not have had at some time under consideration the system represented by the other solution of the equations, which would have conducted to forms approximating very nearly to the system of Gauss.

Five hundred and twenty-seventh Meeting.

November 11, 1863. — STATUTE MEETING.

The PRESIDENT in the chair.

Professor Cooke reported that no purchases of books for the Library had been made since the annual meeting. The Academy voted to continue without change the list of periodicals.

The President presented the following report from the Council: —

* The refractive and dispersive powers in III., and probably in II., differ by small amounts from those used in computing IV. and V.; moreover, in the latter, the effect of the thickness of the lenses and of their distance from each other has not been included, so that the numbers to be strictly comparable would require a small correction. The values V., computed with the elements of refraction and dispersion used for III., neglecting only the correction for thickness, become

	ft.
+	14.212
+	6.349
—	6.488
+	25.375
	21.00

A proposition in reference to the administration of the Vatican Library, laid before the Academy at the anniversary meeting, was referred to the Council for consideration.

The Council is deeply sensible of the interest and importance of the movement proposed by Dr. Beck. The system adopted by the Papal Authorities for the use, or rather the *disuse*, of the literary manuscripts of that great collection, has been explained to the Council by Dr. Beck, from his own experience. Nothing can be more desirable to those engaged in historical and philological investigations, nor more useful to the cause of learning, than the relaxation of the rigid rules which virtually exclude scholars from all inspection and examination of the manuscripts in the Vatican. Learned men, and especially learned societies throughout the world, it is thought, may with propriety protest against this system, and solicit a change.

The Council would suggest, however, that the Academy may wisely refrain from adopting the political expressions contained in the preamble with which the resolves under consideration are connected; and would also express the opinion, that, in view of the importance and delicacy of this subject, its practical consideration may advantageously be devolved upon a committee of the executive officers of the Academy, who can, at their discretion, seize upon any favorable opportunities that may offer from time to time for the representation of the case; acting under the following resolution, — which is herewith reported as a substitute for those referred to its consideration, viz. : —

Resolved, That the President, Vice-President, and the Secretaries of the Academy be a committee to correspond with the American Minister at Rome, and also with the American Minister at Turin, if they think it expedient, on the subject of securing greater liberality in the administration of the Library of the Vatican, and particularly with a view to secure to scholars an opportunity of examining its rare and valuable manuscripts.

The resolution was adopted.

The vacancy in the Rumford Committee, occasioned by the resignation of Professor Eliot, was filled by the election of Professor Gibbs.

Henry C. Carey of Philadelphia, and George Bancroft of New York, were elected Associate Fellows, in Class III., Section 4.

John P. Kennedy of Baltimore, and Frederic E. Church of New York, were elected Associate Fellows, in Class III., Section 4.

William Lawrence of London was elected a Foreign Honorary Fellow, in place of the late Sir Benjamin C. Brodie, of Class II., Section 4.

Dr. Edward Jarvis was elected Resident Fellow in Class II., Section 3.

Professor Bond communicated "A List of New Nebulæ seen at the Observatory of Harvard College, 1847-1863."

An examination of the notes relating to the positions and appearance of nebulae and star-clusters, occurring in the record-books of the Observatory for the last fifteen years, has furnished the accompanying list of objects which have not been identified in published catalogues. As the number of observations compared has amounted to several hundred, most of the nebulae of course having been previously seen elsewhere, it is quite possible that a few of those entered on the list may be accounted for by errors in the observed places, or by supposing them to be merely groups of a few small stars indistinctly seen. This might the more easily have happened, since the nebulae have, in most instances, been met with by accident, while sweeping for comets, or in the passage of zones of stars. In such cases, but little time could be given to determining the positions, or to a close scrutiny of the object; the list has been divided into two sections, the second comprising objects rather doubtful as to their position or identity as nebulae.

I. *List of new Nebulae and Star-clusters seen at the Observatory of Harvard College.*

(1.) A small faint nebula, 1' north-following a star of the 11th magnitude, seen Sept. 16th, 1863, by G. P. Bond, with the Great Refractor.

$$1863.0 \alpha = 0^h 35^m 10^s.2 \pm 0^s.4 \quad \delta = + 0^\circ 8' 54'' \pm 20''$$

(2.) A small, round, pretty bright nebula, diameter 45'', seen Jan. 5th, 1853, by G. P. Bond, with the Great Refractor. (In Harvard Zones.) Re-observed Sept. 16th, 1863.

$$1863.0 \alpha = 0^h 35^m 15^s.2 \pm 0^s.4 \quad \delta = + 0^\circ 5' 24''.0 \pm 15''$$

The nebulae h. 39 — 41 and 43 precede the above nearly in the same declination.

(3.) A faint nebula $1' 30''$ south-following a star of the 11th magnitude, seen Jan. 8th, 1853, with the Great Refractor, by G. P. Bond. (In Harvard Zones.)

$$1853.0 \alpha = 0^h 59^m 52^s \quad \delta = + 0^\circ 8' 52''$$

(4.) A faint nebulosity, seen Jan. 25th, 1860, by Sidney Coolidge, with the Great Refractor. (In Harvard Zones.)

$$1860.0 \alpha = 3^h 6^m 55^s.2 \quad \delta = + 0^\circ 55' 32''.5$$

(5.) A faint nebulosity, seen Dec. 16th, 1859, by Sidney Coolidge, with the Great Refractor. (In Harvard Zones.)

$$1860.0 \alpha = 3^h 16^m 29^s.0 \quad \delta = + 0^\circ 40' 57''.0$$

(6 and 7.) Two clusters, seen March 19th, 1863, by T. H. Safford, near two stars of the 10-11th magnitude, with the Great Refractor. (In Harvard Zones.)

$$\begin{aligned} \text{Positions of stars:—} 1863.0 \alpha &= 6^h 4^m 44^s.9 & \delta &= + 1^\circ 8' 37'' \\ &= 6 \ 5 \ 47.2 & &= + 1 \ 10 \ 2 \end{aligned}$$

(8.) A cluster, seen March 19th, 1863, by T. H. Safford, between two stars in the following position, with the Great Refractor. (In Harvard Zones.)

$$\begin{aligned} \text{Star of 10-11 mag. } 1863.0 \alpha &= 6^h 6^m 27^s.8 & \delta &= + 1^\circ 1' 10'' \\ \text{" } 9-10 \text{ " } &= 6 \ 7 \ 12.7 & &+ 1 \ 0 \ 27 \end{aligned}$$

(9 and 10.) Two faint nebulae seen Feb. 26th, 1853, with the Great Refractor, by G. P. Bond. (In Harvard Zones.)

$$1853.0 \alpha = 7^h 22^m 15^s \quad \delta = + 0^\circ 5' 11''$$

It is not stated to which one of the pair this position belongs. The two are probably quite near each other.

(11.) A very faint comet-like nebula, seen Sept. 1st, 1852, with the Great Refractor, by G. P. Bond.

$$1852.0 \alpha = 7^h 54^m 44^s \quad \delta = + 20^\circ 35'.8$$

Nebula north-preceding star of 9th mag. B. Z. 277

$$\Delta \alpha = - 0^m 27^s.05 \quad \Delta \delta = + 2' 42''.2$$

(12.) A nebulous object, seen March 31st, 1859, by Sidney Coolidge, with the Great Refractor. (In Harvard Zones.)

$$1859.0 \alpha = 9^h 59^m 48^s \pm 4^s \quad \delta = + 0^\circ 45'.0 \pm 2'$$

(13.) A faint nebulous object, seen March 31st, 1859, by Sidney Coolidge, with the Great Refractor. (In Harvard Zones.)

$$1859.0 \alpha = 10^h 16^m 11^s \quad \delta = +0^\circ 46' 31''$$

(14.) A star of 12th magnitude in a faint nebulosity, seen May 3d, 1859, by Sidney Coolidge, with the Great Refractor. (In Harvard Zones.)

$$1859.0 \alpha = 12^h 30^m 57^s.4 \quad \delta = +0^\circ 57' 33''.4$$

(15.) A star of 12th magnitude in a faint nebulosity, seen April 30th, 1859, by Sidney Coolidge, with the Great Refractor. (In Harvard Zones.)

$$1859.0 \alpha = 13^h 24^m 29^s.9 \quad \delta = +0^\circ 41' 49''.0$$

(16.) A star of 12th magnitude slightly nebulous, seen April 30th, 1859, by Sidney Coolidge, with the Great Refractor. (In Harvard Zones.)

$$1859.0 \alpha = 13^h 42^m 35^s.2 \quad \delta = +0^\circ 46' 15''.7$$

(17.) A small round nebula, seen June 8th, 1855, by G. P. Bond, with the Great Refractor. (In Harvard Zones.) Distant 2' from a star of the 9th mag. in the position

$$1855.0 \alpha = 13^h 49^m 3^s \quad \delta = +0^\circ 30' 20''$$

(18.) A nebulous star of 12th magnitude, seen April 29th, 1859, by Sidney Coolidge, with the Great Refractor. (In Harvard Zones.)

$$1859.0 \alpha = 13^h 53^m 54^s.9 \quad \delta = +0^\circ 46' 24''.3$$

(19.) A nebula seen May 9th, 1853, with the Great Refractor, by G. P. Bond. (In Harvard Zones.)

$$1853.0 \alpha = 14^h 21^m 48^s \quad \delta = +0^\circ 13' 9''$$

(20.) A round nebula seen May 9th, 1853, with the Great Refractor, by G. P. Bond. (In Harvard Zones.)

$$1853.0 \alpha = 14^h 23^m 39^s \quad \delta = +0^\circ 20' 9''$$

(21.) An elongated nebula, fainter than the above, seen May 9th, 1853, by G. P. Bond, with the Great Refractor. (In Harvard Zones.)

$$1853.0 \alpha = 14^h 24^m 24^s \quad \delta = +0^\circ 17' 9''$$

(22.) An elongated faint nebula, longest diameter 80'', seen Sept. 1st, 1859, with the Comet-seeker, by H. P. Tuttle.

$$1859.0 \alpha = 18^h 23^m 37^s \quad \delta = +74^\circ 30'.2$$

The position given is that adopted by Auwers, William Herschel's *Verzeichnisse von Nebelflecken und Sternhaufen*, p. 75.

(23.) A faint nebula following a star of the 10th magnitude $0^m 1^s.0$, and $1' 29''$ north of it, seen Nov. 24th, 1852, by G. P. Bond, with the Great Refractor. (In Harvard Zones.)

$$1852.0 \alpha = 19^h 56^m 14^s.5 \quad \delta = +0^\circ 1' 48''$$

(24.) A nebula seen Feb. 10th, 1848, by G. P. Bond, with the Great Refractor.

$$1848.0 \alpha = 21^h 44^m 46^s \quad \delta = +49^\circ 2' 9''$$

(25.) A nebula seen Oct. 23d, 1848, with the Great Refractor, by G. P. Bond.

$$1848.0 \alpha = 23^h 24^m 56^s \quad \delta = -6^\circ 26' 10''$$

Nebula north-preceding star of 9th mag.

$$\Delta \alpha = -0^m 18^s.19 \quad \Delta \delta = +1' 12''.7$$

II. The following are the positions of objects supposed to be nebulae, but requiring verification.

(26.) A nebula quite faint, $3^\circ 30'$ north of γ Cassiopeia, and in the same right ascension with it. Seen Feb. 27th, 1850, by G. P. Bond, with the Comet-seeker.

$$1850.0 \alpha = 0^h 47^m 41^s \pm 1^m \quad \delta = +63^\circ 24' \pm 10'$$

Looked for, but could not be found, Sept. 9th, 1863.

(27.) A faint, small, round nebula 8° north-preceding Capella. Seen by G. P. Bond with the Comet-seeker, Feb. 18th, 1851.

$$1851.0 \alpha = 4^h 33^m + 3^m \quad \delta = +53^\circ 0' \pm 30'$$

(28.) A small nebula, seen near κ Orionis, Oct. 6th, 1850, by G. P. Bond, with the Comet-seeker.

$$1850.0 \alpha = 5^h 37^m 43^s \pm 20^s \quad \delta = -10^\circ 8' 39'' \pm 5'$$

(29.) A nebulous object (?), seen May 3d, 1859, by Sidney Coolidge, with the Great Refractor. (In Harvard Zones.)

$$1859.0 \alpha = 12^h 12^m \quad \delta = +0^\circ 56'$$

(30.) A faint, rather large nebula, one third of the distance from Arcturus to α Corona Borealis, and in a line with the last-named star. Seen by G. P. Bond with the Comet-seeker, Dec. 30th, 1850.

$$1850.0 \alpha = 14^h 37^m \pm 3^m \quad \delta = +23^\circ 0' \pm 30'$$

Looked for, but not found, Aug. 17th, 1863.

(31.) A nebulous star, seen Nov. 15th, 1859, by Sidney Coolidge, with the Great Refractor. (In Harvard Zones.)

$$1859.0 \alpha = 22^h 46^m \quad \delta = +0^\circ 44'$$

(32.) A nebula resembling a comet, seen Nov. 7th, 1850, by G. P. Bond, with the Comet-seeker.

$$1850.0 \alpha = 23^h 50^m 46^s \quad \delta = -33^\circ 24'$$

III. Positions of known nebulae have been observed as follows:—

h. 555. Faintly seen in the Comet-seeker, March 25th, 1852. Compared by G. P. Bond with a star of 9.5 mag. Arg. Sternverzeichniss $+60^\circ 1175$. Nebula south-following star.

$$\Delta \alpha = +0^m 26^s.25 \quad \Delta \delta = -1' 57''.8$$

h. 90. Compared with a star of 7th magnitude B.A.C. 357, by G. P. Bond. Nebula north-preceding star.

$$\Delta \alpha = -0^m 43^s.0 \quad \Delta \delta = +2' 44''.5$$

The nebula discovered by Schönfeld in 1858, and numbered 17 in Auwers's catalogue of new nebulae, was also discovered independently by H. P. Tuttle, Feb. 5th, 1859, as "a nebulosity attached to a star of the 9–10 mag. which follows its centre six seconds and is two minutes north of it." It was visible in the Comet-seeker and in the Finder of the Great Refractor. No. 45 of the same catalogue, discovered by Winnecke in 1853, was also discovered independently by H. P. Tuttle, July 27th, 1859. It appeared as a faint cometary object in the Comet-seeker, but in the Great Refractor as a cluster just resolved of $2'$ or $3'$ in diameter.

The nebula H, III. 447 was observed Feb. 7th, 1863, with the Great Refractor, by G. P. Bond. Diameter $40''$, with a faint star or appendage on the north-following side.

Nebula north-preceding star of 8th mag. H. C. 10303, Sept. 9th, 1863.

$$\Delta \alpha = -0^m 34^s.10 \quad \Delta \delta = +2' 47''.3$$

The nebula H, I. 288 was observed by G. P. Bond, April 8th, 1859, as follows:—

Nebula north-following star α of 7–8th mag. Oeltzen 9183.

$$\Delta \alpha = +5^m 0^s.88 \quad \Delta \delta = +4' 15''.5$$

Nebula north-preceding star b of 8–9th mag. Oeltzen 9305.

$$\Delta \alpha = -2^m 57^s.75 \quad \Delta \delta = +4' 15''.5$$

The nebula H. IV. 33, in the position $1830.0\ 5^h\ 28^m\ 7^s$, $\delta\ -6^\circ\ 51'$, described by W. Herschel as "a star with a milky chevelure or v. B. nucleus with milky nebulosity," appears in the Great Refractor as a fine annular nebula or cluster, very much concentrated on the following side almost to a stellar centre.

Professor Cooke gave a description of a new and improved Spectroscope made by Mr. Alvan Clarke. It has nine prisms of plane glass sides filled with bisulphide of carbon, which are so mounted and arranged that they are capable of easy adjustment to the angles of least deviation in the refracted ray. By this instrument Professor Cooke has been able to discover a much greater number of lines in the solar spectrum and in metallic spectra than have hitherto been observed.

Dr. Gray presented the two following papers: —

On STREPTANTHUS, Nutt., and the Plants which have been referred to that Genus. By ASA GRAY.

A number of plants have been referred to *Streptanthus*, — some by its founder, Nuttall, and others by myself, — which, upon re-examination, appear to belong elsewhere. Having now before me all the authentic materials which exist in herbaria in this country, I have endeavored to clear up the group, with the following results.

1. STREPTANTHUS, Nutt.

The characters of this genus are the linear or elongated and sagittate anthers, and petals with long canaliculate claws (with or without a dilated lamina), along with the flattened siliques and broad flat seeds of *Arabis*. *Iodanthus*, Torr. & Gray, and *Thelypodium*, Endl. (*Pachypodium*, Nutt.), which have long unguiculate petals and narrow anthers (which coil or curve when effete, like those of *Streptanthus*), have terete and torulose siliques, the valves with an obscure if any mid-nerve, and oblong seeds, the cotyledons in the latter obliquely more or less incumbent. There are transitions which connect, quite too closely, *Streptanthus* with *Arabis*. But the genuine species of the former are so strikingly marked, that the genus will probably be kept up. The disposition of the calyx to assume a crimson or purple color, and of the filaments of the longer stamens to unite in pairs, may also be taken into account. I recognize the following species.

§ 1. *EUSTREPTANTHUS*, Endl. Petals with a broad and ample plane lamina. Sepals suberect or erect. Seeds winged. Flowers pretty large, rose-purple. Cauline leaves all sessile and cordate-clasping, glabrous and more or less glaucous.

* Flowers all subtended by persistent bracts.

1. *S. BRACTEATUS*, Gray, Gen. Ill. 1, t. 60; Pl. Lindl. 2, p. 143, & Pl. Wright. 2, p. 11. Silique elongated-linear, 6 inches long, spreading. Mature seeds not seen. — Texas.

* * Flowers (or all but the lowest) ebracteate.

2. *S. PLATYCARPUS*, Gray, Pl. Wright. l. c. Siliques oblong-linear ($2\frac{1}{2}$ –3 lines wide), very flat, erect. Leaves clasping by rather short and rounded lobes, the lower and radical ones lyrate-pinnatifid. — S. W. Texas.

3. *S. MACULATUS*, Nutt. in Jour. Acad. Philad. 5, p. 134, t. 7. *S. obtusifolius*, Hook. Bot. Mag. t. 3317. *Brassica Washitana*, Muhl. Cat. ? Siliques narrowly linear (only a line wide, 3 or 4 inches long), erect or ascending. Cauline leaves clasping by long and obtuse lobes, making a very deep and nearly closed sinus. — Arkansas and E. Texas.

§ 2. *EUCLISIA*, Nutt. Petals undulate-crisped, the lamina narrow or attenuated, scarcely if at all broader than the claw. Sepals connivent, mostly colored, often saccate at the base. The longer stamens often connate.

* Flowers distinctly pedicelled. Stem not fistulous-inflated.

+ Wholly glabrous and mostly glaucous: cauline leaves clasping by a cordate or sagittate base.

4. *S. CARINATUS*, C. Wright, in Gray, Pl. Wright. 2, p. 11. Flowers purple (half an inch long); the urceolate calyx carinately 5-saccate. Pedicels of the flowers and of the broadly linear and flat (half-grown) siliques erect. Radical and lower cauline leaves runcinate-pinnatifid, the upper ones sagittate-clasping, all very glaucous. Seeds unknown. — S. W. Texas, below El Paso.

5. *S. CORDATUS*, Nutt. in Torr. & Gray, Fl. 1, p. 77. This, although marked with the exclamation point, as having been authenticated, is not preserved in any American herbarium, so far as I can ascertain. It is characterized by Nuttall as having very obtuse leaves, toothed near the summit, the cauline cordate and clasping, greenish-

yellow flowers on short pedicels, an oblong campanulate calyx, and deflexed siliques. The locality assigned by Nuttall is "Forests of the Rocky Mountains." An imperfect specimen gathered "on the Colorado" by Dr. Newberry may be of this species. Otherwise it is wholly unknown to me. I suppose it can be neither the foregoing nor the following species.

6. *S. TORTUOSUS*, Kellogg, in Proceed. Calif. Acad. 2, p. 152, t. 46, wood-cut. *S. cordatus*, Torr. Bot. Whipl. Exped. Pacif. R. R. Surv., p. (65) 9, not of Nutt. Flowers purple, on slender (spreading or ascending) pedicels, in a lax raceme, the lowermost often leafy-bracted, half an inch long; the (ovate) buds and the sepals usually long-acuminate. Siliques, according to Dr. Kellogg's figure and description, narrowly linear and falcately recurved-spreading. Seeds, according to Dr. Kellogg's description, wing-margined. Leaves entire or denticulate, the cauline cordate-clasping and mostly appearing as if perfoliate. Stem paniculately branched. — Dr. Kellogg's uncharacteristic name for this species refers only to the areolation of the septum of the silique. — California, on the Yuba River, Dr. Bigelow; and "the Copper region of the Sierra Nevada, Mr. C. D. Gibbs," Dr. Kellogg. The habitat is remote from that assigned for his *S. cordatus* by Nuttall, who, moreover, could never have omitted to notice the taper-pointed flower-buds and sepals, so conspicuous in Dr. Bigelow's specimens and Dr. Kellogg's figure. But I must remark that two specimens in Dr. Torrey's herbarium, collected in California by Mr. Gibbs (I presume the person who supplied Dr. Kellogg) have flowers with nearly obtuse buds and sepals, but in size and all other respects like the *S. tortuosus*. The "wing-margined seeds," noted by Dr. Kellogg, who alone has seen the fruit, should aid in distinguishing this species from the next.

7. *S. BREWERI*, n. sp. (Gray in Proceed. Calif. Acad. ined.) Flowers purple, on very short ascending pedicels, the lowest often leafy-bracted; the buds a quarter of an inch long, obtuse or barely acute; the sepals with scarious but recurved blunt tips. Siliques narrowly linear, ascending or erect, straight or slightly incurved ($1\frac{1}{2}$ – $2\frac{1}{2}$ inches long, less than a line wide), compressed, but torulose, the nerve of the valves obscure. Seeds wholly marginless. Glauous, annual, branched from near the base. Cauline leaves, except the lowest, strongly cordate-clasping with a closed sinus, entire or denticulate, the uppermost sagittate. California; collected in the State Geological Survey by Prof. William H. Brewer, at three stations, under the following forms:—

1st. In a dry ravine of Shasta Mountain, at the elevation of 8000 feet: a dwarf state, in flower only, a span high; the foliage resembling that of *Thlaspi perfoliatum*. 2d. On the Diablo Mountains, five degrees farther south, on the top of a dry mountain, alt. 3200 feet; in flower and fruit, 9 inches high. Flowers rather smaller, more numerous. Lower cauline leaves 2 inches long, very glaucous. 3d. On San Carlos, of the Mount Diablo range: in flower and fruit, with more naked and virgate branches, one or two feet high; the calyx hoary or downy, but otherwise the plant is quite glabrous and glaucous, as in the other forms.

+ + Wholly glabrous and somewhat glaucous: cauline leaves not cordate nor auriculate at the base, entire or very obscurely toothed. Flowers violet-purple.

8. *S. hyacinthoides*, Hook. Bot. Mag. t. 3516; Gray, Gen. Ill. 2, t. 61. *S. glabrifolius*, Buckley in Proceed. Acad. Philad. Flowers in the virgate raceme spreading and soon pendulous, green and violet-purple; the calyx cylindraceous. Siliques erect-spreading (2-4 inches long, a line wide). Seeds with a narrow wing. Leaves linear-lanceolate and oblong-linear.—E. Texas and the adjacent part of Arkansas.

+ + + More or less furnished with bristly simple hairs: cauline leaves or some of them usually auriculate- or sagittate-clasping and laciniate-toothed. Flowers, at least the calyx, crimson-purple or red.

9. *S. GLANDULOSUS*, Hook. Ic. t. 40. Cauline leaves narrowly lanceolate and mostly sagittate-clasping, their sparse teeth with callos rather than glandular tips. The lax raceme with the pedicels and flowers glabrous or nearly so; calyx ovate. Siliques narrowly linear (2 or 3 inches long, less than a line wide), straight or curved, ascending. Immature seeds slightly wing-margined. The cauline leaves are commonly sagittate and the siliques glabrous. But Dr. Brewer has collected a form with the leaves slightly auricled at the base, and the siliques beset with a few bristles.—California.

10. *S. HETEROPHYLLUS*, Nutt. in Torr. & Gray, l. c. Cauline leaves oblong and lanceolate and sagittate-clasping, mostly hispid. Pedicels in the lax raceme spreading in flower, deflexed in fruit, commonly (as well as the calyx) more or less hispid. Siliques deflexed, straight, very narrowly linear, teretish-subtetragonal, 3 or 4 inches long,

glabrous, tapering at the summit into a distinct style. Seeds wingless. In Nuttall's original specimens all but the lower pedicels and also the calyx are glabrous: in those of Coulter and of Xantus they are hispid, especially the pedicels. They have, in the fruit, a strongly 2-lobed stigma. In Nuttall's the stigma is only emarginate. — Southern part of California.

11. *S. HISPIDUS*, n. sp. (Gray in Proceed. Calif. Acad. ined.) Very dwarf (2 or 3 inches high, from an annual root), hispid throughout, even to the siliques. Leaves cuneate or obovate-oblong, coarsely toothed or incised, the cauline sessile, but hardly at all clasping. Raceme short and loosely flowered: pedicels spreading or at length recurved, but the linear compressed siliques ($1\frac{1}{2}$ inch long and a line wide) are erect. Stigma emarginate, almost sessile. Immature seeds winged. The flowers resemble those of the preceding species. The anthers are rather short for this genus, only linear-oblong, and blunt; but the longer filaments are connate. The whole body of the petal is a long, linear lamina, the base of which is contracted into a narrow claw. — California; on the dry summit of Monte Diablo, coll. William H. Brewer, California State Geological Survey.

+ + + + Sparingly hirsute with simple hairs or nearly glabrous: cauline leaves not clasping nor auriculate at the base, the lower sinuate or pinnatifid and contracted at the base into a margined petiole. Flowers yellowish or greenish-white.

12. *S. FLAVESCENS*, Hook. Ic. t. 44. Flowers ascending: calyx cylindraceous. Siliques erect, glabrous or sparingly hairy, teretish, pointed with a distinct style. Seeds probably wingless. — California. A very large or luxuriant form of this was gathered at the coal-mine near Monte Diablo by Dr. Brewer, 2 or 3 feet high, the lower leaves runcinate, the "greenish-white" flowers half an inch long; siliques half-grown.

* * Flowers sessile or nearly so. Stem fistulous-inflated.

13. *S. CRASSICAULIS*, Torr. in Stansbury, Rep. Salt Lake Exped. p. 384, t. 1. Leaves mostly radical, runcinate-pinnatifid. Calyx woolly. Petals dark purple. Silique unknown. — Utah.

Doubtful Species.

S. REPANDUS, Nutt. in Torr. & Gray. Fl. 1, p. 77, of the *Euchisia* section, from Santa Barbara, California, is known only from Nuttall's brief character.

2. *Species excluded from Streptanthus.*

S. sagittatus, Nutt. in Jour. Acad. Philad. 7, p. 12. The scanty original specimens of Wyeth are in flower only. The *S. sagittatus* of Hooker and Arnott, from the Snake Country (which in the suppl. to Fl. N. Amer. vol. 1, was referred to *S. angustifolius*, Nutt.) is apparently the same with smaller flowers. These specimens show a torulose terete silique and oblong seeds, in which the cotyledons probably are not truly accumbent. They are identical with *Pachypodium* (*Thelypodium*) *sagittatum*, Nutt. in Torr. & Gray, Fl.; and so, likewise, we may regard the larger-flowered specimens, until their fruit is known.

S. angustifolius, Nutt. in Torr. & Gray, Fl. l. c. To this certain narrow-leaved and smaller-flowered forms of the preceding species have been subsequently referred. But Nuttall's specimens, on which the species was founded, belong to *Turritis patula*, Graham, which is as good an *Arabis* as need be, — therefore *Arabis patula*.

S. angustifolius, Gray in Proceed. Acad. Philad. March, 1863, p. 67, coll. Hall and Harbour, no. 35, is *Turritis brachycarpa*, Torr. & Gray, Fl., a short-fruited form of *T. stricta*, Graham, which is a true *Arabis*, — *A. Drummondii*.

S. virgatus, Nutt. in Torr. & Gray, Fl. l. c., although not extant in any of our herbaria, I may rather confidently refer to *Arabis retrofracta*, Graham (*Turritis*, Hook. etc.), and *A. Höllbollii*, Hornem., probably the purple-red-flowered form which occurs west of the Rocky Mountains.

S. arcuatus, Nutt. l. c., which Mr. Wallace and Dr. Brewer have also collected in California, is another genuine wing-seeded *Arabis*, — *A. arcuatus*.

These last, with *Arabis blepharophylla*, Hook. (of which the fruit is unknown), have short, oval or barely oblong anthers, and there is nothing in their flowers to associate them especially with *Streptanthus*.

S. petiolaris, Gray, Pl. Fendl. &c. (to which belongs *S. Brazoensis* of Buckley), having short anthers, &c., must be referred to the wing-seeded division of *Arabis*, — *A. petiolaris*.

S. longifolius, Benth. Pl. Hartw. and *S. micranthus*, Gray, Pl. Fendl. (which is perhaps a form of *S. longifolius*), with short anthers, very narrow siliques, and wingless seeds, may probably be referred to *Arabis*. But the valves are so carinate that the silique appears almost tetragonal.

S. linearifolius, Gray, Pl. Fendl., has elongated acute anthers, in-

deed, and long-clawed petals; but, with its almost terete siliques, having an obscure stipe, and oblong seeds, it best accords with *Iodanthus*, Torr. & Gray, — which genus, again, is not well, if at all, to be distinguished from *Pachypodium*, Nutt. (*Thelypodium*, Endl.), and this name, though badly chosen, may have to be adopted. It would be better if we could settle upon the name of *Thelypodium*.

No. 684 (or 689?) of Coulter's Mexican collection, from Zimapan, appears to be a strict congener of *Iodanthus pinnatifidus*.

*A Revision and Arrangement (mainly by the fruit) of the
North American Species of ASTRAGALUS and OXYTROPIS.*

By ASA GRAY.

In view of the species known to him by the fruit, it was natural enough that Linnæus should distinguish from *Astragalus* his genus *Phaca*. Being established, and augmented with a considerable number of species, it is not surprising that the two genera should still have been maintained long after the neat carpological character which alone distinguished them was found in some cases to fail. Perhaps there are not very many large genera in botany which do not at some point graduate into some other. But in the present case, — not to refer to the eminent unsafeness of all leguminous genera founded on the legume alone, and to the inutility of genera which are not recognizable by habit or floral structure, — it has now become evident that the distinction between *Phaca* and *Astragalus* breaks down so completely and so variously, that the two genera are, as I suppose, no longer tenable. Indeed, from analogous instances we might expect that the intrusion into the cell of one or the other suture, even when, as here, quite constant in species, would not of itself be of generic consequence. An obvious alternative to combining these two Linnæan genera is to proceed further in division, by taking the form and texture of the legume into generic account. The manifold diversity which the fruit exhibits, and also the vastness of the group, would invite to this course. But a study even of the North American species only — especially as here grouped mainly in reference to the fruit — demonstrates its impracticability. In place of two genera with outlines here and there blended, we should have twenty, most of them still less definable. A partial attempt of this kind, probably one of the best that could be made, was that of Nuttall, in proposing his two genera, *Homalobus* and *Kentro-*

phyta, upon flat-podded species of what would otherwise belong to *Phaca*, the single species of the latter and some species of the former being quite peculiar in habit. But intermediate forms connect the compressed with the turgid and inflated legumes.

Used for sectional groups, these minor carpological characters may be turned to good practical account; for it is no great objection to such natural groups, as it is to genera, that they blend through gradations or have occasional exceptions.

It is in the botany of this country that the question of the distinction between *Phaca* and *Astragalus* is most pressing, and where the *data* for the answer are most largely to be found. While extra-tropical Asia is the focus of true *Astragalus*, that of *Phaca* is in America, mainly in North America, with an extension along the Andes into South America. While the Flora of the Russian Empire enumerates 168 species of *Astragalus* (of which I suppose more than nine tenths are bilocellate or nearly so), and only six species of *Phaca*, I recognize in the following paper 66 species of the *Phaca* series to 52 of *Astragalus* proper. Moreover, rather less than half of the latter are completely bilocellate by a dorsal septum, and at least half a dozen, of different groups, have been or might be referred to *Phaca*. *A. aboriginum*, *A. Robinsii*, &c. are retained in the *Astragalus* series, on account of the vanishing rudiment of a dorsal septum; and *A. lotiflorus* chiefly, and *A. microlobus* entirely, because of their close affinity to cognate Astragaline species; while, on the other hand, *A. Cooperi* and *A. Beckwithii*, associated with their natural allies among the *Phacæ*, might technically be about as well placed in the other series.

I cannot avoid the conclusion that *Phaca* must be merged in *Astragalus*. Also, — since in perhaps the majority of the *Phacæ* there is no intrusion nor peculiar tumidity of the seminiferous suture, — that the subtribe *Astragaleæ* of De Candolle has no valid foundation, so that *Astragalus* is merely a genus of the *Galegeæ*.

The combination of *Phaca* with *Astragalus* at once leads us to consider the case of *Oxytropis*. This is a genus founded by De Candolle upon Linnæan species of *Astragalus*, and now pretty numerous in species. It is characterized by having, along with the legume of *Phaca*, carried sometimes to an extreme (that is, with the ventral suture septiferous), a beak-like acumination or cusp at the apex of the carina of the corolla, — whence the generic name. Thus *Oxytropis*, strictly considered, would now appear to rest upon this cusp or tip alone.

This tip, moreover, while sometimes conspicuously prominent, is obsolete or barely perceptible in one or more species of every group the genus comprises. We have in North America only 8 species of *Oxytropis*, all northern or montane; and Europe has about as many; but the Flora of the Russian Empire boasts of sixty-one species. Ought *Oxytropis* to be retained as a genus? On the one hand there is a general congruity of the species in habit; on the other, *O. Lapponica*, with the technical generic character almost obliterated, and others of that group, very closely resemble species of *Astragalus* with which they are geographically associated. Moreover, the technical generic character is of no such value in *Indigofera*.

Probably the best support of the genus, notwithstanding the reduction of *Phaca* to *Astragalus*, has been the constant coincidence of the pointed keel of the corolla with the introflexion of the ventral suture; in other words, that no *Astragali*, in the strict sense, are known with a pointed keel. There are, however, among American species some *Astragali* and *Phacæ* with the keel either considerably attenuated upwards or acutish. And at length we have one from Arizona, described at the end of the genus, under the name of *A. nothoxyis*, which, along with the habit and the dorsally bilocellate legume of a true *Astragalus*, has in the corolla a sharply acuminate keel! Still, although *Oxytropis* could hardly be more completely invalidated than by this discovery, I think it probable that it may still be kept up, on the ground of general convenience.

If *Phaca* must needs be merged in *Astragalus*, it is obviously desirable that the change should be made as soon as possible, and the requisite alterations in nomenclature effected. Moreover, our species greatly needed revision, and reduction to some systematic arrangement. In this view, having obtained from their obliging proprietors the important materials in the herbaria of Dr. Torrey, Mr. Durand, and of the Philadelphia Academy (containing the types of most of Nuttall's species), and collated them with those of my own herbarium, I have devoted much time to the study of these plants; and the result is herewith presented.

The general order is from the completely bilocellate legumes, through the imperfectly bilocellate, to the strictly unilocular species; with no attempt (which would be hopeless) to dispose the groups in any natural series. When brought into proper form for a systematic work, the groups themselves would be considerably condensed, reduced, or subordinated.

1. ASTRAGALUS, *Tourn.*

CLAVIS.

I., II. Corollæ carina obtusa. Sp. legitimi, 1-108.

III. Corollæ carina acutissime acuminata. Legumen Astragolorum typicorum.
Sp. anomala, 109.

I. Legumen sutura dorsali intrusa vel impressa bilocellatum aut subseptatum,
sutura ventrali in unilocularibus nullo modo seu minus quam dorsalis
intrusa. ASTRAGALUS, L., DC. Sp. 1-52.

Legumen septo completo bilocellatum, didymum, locellis 1-2-ovulatis. § 8.

Legumen septo completo bilocellatum breve, locellis 3-4-ovulatis, estipitatum,
Ovato-trigonum, crasso-coriaceum, dorso profundissime sulcatum bipartitum.
Flores parvi, albo-violacei : carina corollæ falcato-attenuata. § 7.

Turgido-ovatum, tenui-coriaceum, sulco levi. Flores parvuli, flaviduli. § 3.

Legumen septo completo manifesto bilocellatum, locellis 5-multi-ovulatis, haud
(in sp. no. 14 brevissime) stipitatum.

Crasso-succulentum, exsiccatum parietibus medullosis. § 1.

Membranaceum, vesicario-inflatum, septo versus medium seminifero. § 2.

Coriaceum vel subcartilagineum.

Oblongum, teres, dorso anticeque subsulcatum. Subacaules, villo sericeo mol-
lissimo splendentes : flores speciosi. § 4.

Oblongum, teres, nec antice vix postice sulcatum. Elati, glabelli ; flores haud
amœni. § 5.

Oblongum, ovatum seu lineare, postice bicarinatum vel profunde sulcatum,
sectione transversali obcordata vel e dorso biloba vel Y-formi.

Stipulæ adversus folium pl. m. connatæ. Flores spicati vel capitati, medi-
ocres. Legumen oblongum, compresso-trigonum, pubescens seu villo-
sum. § 6.

Stipulæ discretæ.

Flores parvi seu parvuli ; calycis tubo brevi. § 9.

Flores majusculi ; calycis tubo cylindrico. Legumen lineari-elongatum,
glaberrimum. § 10.

Legumen septo incompleto seu nullo uniloculare, sub-bilocellatum, vel sutura dor-
sali ventralem attingente interstinctum quasi bilocellatum,

Stipitatum. § 11, et pro parte § 14.

Estipitatum.

Stipulæ omnes alte folium adversus connate. § 12.

Stipulæ præter inferiores discretæ liberæ.

Legumen 6-7-ovulatum floresque (purpurei) minimi. § 13.

Legumen pluri-ovulatum, sat magnum, raro parvulum,

Vix ac ne vix obcompressum : calyx brevis.

Flores albi, violacei, seu purpurei. § 14.

Flores flavidi. Calycis dentes elongati. § 15.

Maturitate obcompressum, suturis approximatis. Calycis dentes tubo sæpis-
sime oblongo vel cylindrico breviores. Plantæ albo-sericeæ vel canescentes :
flores violacei seu purpurascens. § 16.

II. Legumen sutura dorsali haud vel minus quam ventralis intrusa seu impressa plane uniloculare. PHACA, L., DC. Sp. 53-108.

1. Pinnatifolii, rarius abortu paucifoliolati seu aphylli, quandoque simplicifolii. Sp. 53-106.

Legumen lanosissimum, coriaceum. Herbæ lanuginosæ. § 17.

Legumen glabrum, inflatum, majusculum, sutura ventrali manifeste intrusa. § 18.

Legumen glabrum vel pubescens (nunquam sub lana longa occultum), sutura neutra intrusa, ventrali nunc intus prominula,

Membranaceum, inflatum, nec compressum,

Vesicarium, magnum seu majusculum, sæpe stipitatum. § 19.

Vesicarium, subglobosum, parvum, haud stipitatum. § 21.

Elongato-cylindricum, stipitatum. § 20.

Coriaceum, antice concavum sutura cariniformi percursum, stipitatum. § 22.

Cartilagineum, breve, teres, haud stipitatum, suturis utrisque crassis extus prominentibus.

Flores subpollicares, albi. Foliola persistentia. § 23.

Flores purpurei leguminaque minimi. § 13, pro parte.

Coriaceum, ovatum, oblongum, raro cylindricum, vix ac ne vix compressum, sæpius estipitatum. § 24: Cf. § 15 (sp. 46).

Crasso-cartilagineum, compressum, exserte stipitatum, incurvum, suturis validis marginatum. § 25.

Coriaceum vel chartaceum, compressum, rectum seu rectiusculum, suturis nerviformibus marginatum. § 26.

2. Quasi palmatim trifoliolati. Legumen conico-ovatum, parvum, calyce subinclusum. § 27.

Species ignotæ ad calcem.

Series I. Legumen sutura dorsali seu inferiori (carinali) intrusa aut subseptatum aut bilocellatum. (In unilocularibus sutura ventralis neutiquam aut minus quam dorsalis intus tumida vel induplicata.) ASTRAGALUS, L., DC.

§ 1. *Sarcocarpus*. Legumen pruniforme succulentum (exsiccatum parietibus crassis medullosis), indehiscens, in calyce haud stipitatum, septo completo bilocellatum. Radix perennis. Caules foliosi humiles. Stipulæ discretæ fere liberæ. Racemi spiciformes breves.

* Ovarium et legumen glaberrima.

1. A. CARYOCARPUS, Ker. Bot. Reg. t. 176; Gray, Pl. Wright. 1, p. 51 (ubi syn.). *A. carnosus*, Nutt. Gen. (non Pursh, nisi fruct.) *A. succulentus*, Richards.; Lindl. Bot. Reg. t. 1324. *A. pachycarpus*, Torr. & Gray, Fl. 1. p. 332. Pube appressa subcinereus; floribus violaceis; legumine globoso vel ovato plerumque apiculato percrasso. —

Saskatchewan to Texas. *A. pachycarpus*, known only from a single specimen, seems to be only a depauperate state of *A. caryocarpus*.

2. *A. MEXICANUS*, A. DC., Pl. Hort. Genev. 5, p. 7, t. 3. *A. trichocalyx*, Nutt. in Torr. & Gray, Fl. 1, p. 332. Viridior, altior, minus pubescens; floribus albis vel ochroleucis apice purpureo seu violaceo pl. m. tinctis; calyce pube molli brevi albo-villoso vel tomentoso; legumine ovato-globoso vix apiculato. — Plains from the Mississippi River at St. Louis to S. Texas and to the base of the Rocky Mountains. — As this has not yet been found even on the Mexican side of the Rio Grande, the older name of *Mexicanus* should perhaps give way to Nuttall's good name of *trichocalyx*. Some of the Texan forms especially, with less hairy calyx, run much too close to the foregoing species; but, on the whole, this pale-flowered and coarser fleshy-fruited *Astragalus* seems to hold distinct.

* * Ovarium cano-hirsutum: legumen vetustate nunc glabratum.

3. *A. PLATTENSIS*, Nutt. in Torr. & Gray, l. c. *A. caryocarpus*, Torr. in Ann. Lyc. N. Y. Laxe villosum; stipulis majusculis; floribus ochroleucis nunc apice purpureo tinctis; legumine ovato acuminato. — Nebraska to Texas.

Var. *TENNESSEENSIS*. *A. Tennesseensis*, Gray in Chapm. S. Flora. *A. Plattensis*, Gray, Man. addend. 1863, p. 91. Legumen oblongum, subcurvatum. — Prairies of Illinois, and Nashville, Tennessee, to N. W. Alabama.

§ 2. *Diphysi*. Legumen ovatum vel globosum, membranaceum, vesicario-inflatum, fere glabrum, estipitatum, suturis utrisque introflexis pl. m. didymum complete bilocellatum; septo versus medium seminifero; loculis polyspermis. — Multicaules e radice perenni, pube brevi vel subnulla; stipulis discretis petiolo subadnatis. Flores parvuli, albi vel cyanei, spicati vel subcapitati.

* Humiles, glabri vel glabelli; racemis capituliformibus densifloris. Legumen vesicario-ovatum, acuminatum.

4. *A. DIPHYSUS*, Gray, Pl. Fendl. p. 34. Subglaber; foliolis 9–11-jugis confertis carnosulis oblongis; calycis tubo cylindraceo dentibus subulatis duplo longiori; legumine glaberrimo acumine incurvo. — New Mexico, and probably in Utah. Flowers blue or purple, occasionally white. Legume half an inch or more in diameter, grooved down both sides.

5. *A. LENTIGINOSUS*, Dougl. in Hook. Fl. Bor. Am. Hirsutulus; foliolis 8-9-jugis obovatis; calycis tubo campanulato dentibus vix longiori; legumine puberulo demum glabro arcuatim incurvo. — Interior of Oregon and Washington Territory. — Flowers known only from specimens collected in Wilkes's Exploring Expedition near Fort Okanagan. They are much smaller than those of the preceding species, only 4 lines long; the corolla apparently white or purplish. Legumes very much like those of *A. diphysus*, but more incurved, and less sulcate down the outer or dorsal side. It is only in Douglas's specimens that they have been found mottled or freckled.

* * Elatior, cinereus; spicis laxifloris. Legumen globoso-didymum.

6. *A. FREMONTII*, Torr. & Gray, Bot. Whipl. Exped. (Pacif. R. R. Surv. 4), p. 24 (80), excl. var.! Pilis appressis cinereus; caule ultrapedali parcius folioso; foliolis 5-6-jugis ovalibus obovatisve retusis; floribus in spica laxiuscula subsessilibus "purpureis" (lin. 4 longis) patentibus; calycis dentibus tubo longiuscule campanulato brevioribus; legumine glabro globoso apice brevissimo subincurvo postice paullo antice profunde sulcato didymo. — Banks of the Rio Virgen, in the desert of Nevada, between California and New Mexico, Fremont, who alone has met with it. For the specimens referred to this in Dr. Bigelow's collection are probably different. Legume half an inch in diameter, the apex inconspicuous at maturity, although in the forming fruit there is a broad and more manifest acumination. The two sutures meet and unite in the very middle of the cell.

§ 3. *Chaetodontes*. Legumen ovatum, parvum, flore haud longius, estipitatum, coriaceum, turgidum, nunc compressiusculum, postice pl. m. sulcatum, septo completo bilocellatum, locellis 3-4-ovulatis. — E radice perenni multicaules, foliosi, undique villo sericeo albicantes; foliolis angustis sæpius acutis. Flores spicati, parvuli, ut videtur flaviduli, patentes; tubo calycis brevi, dentibus setaceis elongatis corolla parum brevioribus. Stipulæ liberæ, subdiscretæ, subulatæ.

7. *A. CHÆTODON*, Torr. in Bot. Wilkes Expl. Exped. ined. Pedalis; pube villosa; foliolis 10-12-jugis lanceolatis seu oblongo-linearibus (3-6 lin. longis); pedunculis folia superantibus; spica oblonga densa nunc basi interrupta laxiuscula; calyce villosissimo, dentibus tubo longioribus; legumine villosa postice vix sulcato. — Plains on the Kooskooskie River, interior of Washington Territory, Rev. Mr.

Spalding, Dr. Pickering. — Flowers nearly 5 lines long. Bracts setaceous. Legume $2\frac{1}{2}$ or scarcely three lines long, apiculate, under the wool transversely veined, maturing one or two seeds in each cell.

8. *A. LYALLI*, sp. nov. Albo-sericeus; spica brevius pedunculata elongata laxiflora; floribus parvis (lin. 3 longis); calyce villosa, dentibus tubo æquilongis; legumine incano postice profundius sulcato: cæt. præcedentis. — Upper Yakima River, on the boundary between British Columbia and Washington Territory, Dr. Lyall (no. 8, ex herb. Kew.). — Appears different enough from the preceding by the more silky pubescence, and the loosely-spiked flowers of only half the size.

§ 4. *Mollissimi*.* Legumen cartilagineum vel coriaceum, estipitatum, oblongum, turgidum, nec compressum nec obcompressum, ad suturas utrasque pl. m. sulcatum, septo perfecto bilocellatum, demum incurvum. — E caudice perenni subacaules, villo sericeo molli (sæpius fulvo vel aurato) splendentes; pedunculis scapiformibus elongatis. Spicæ densifloræ. Flores inter majores, violacei; calyce tubuloso.

9. *A. MOLLISSIMUS*. Torr. in Ann. Lyc. N. Y. 2, p. 178. Legumen angusto-oblongum, cartilagineum (5–9 lin. longum), glaberrimum, su-

* The materials in our herbaria are too scanty to justify me in meddling with the *Astragali* of the region contiguous to the United States on the south. But there are two very well-marked Mexican species which may be noticed here, viz. *Phaca mollis*, H.B.K., and a new species allied to it. If not referable to the present group, — with some extension of the character as to the legume, making less account of the introflexion of the dorsal suture, — they will constitute a strictly analogous group. The species are: —

A. HUMBOLDTII. *Phaca mollis*, H.B.K. Nov. Gen. & Sp. 6, p. 496, t. 585. Brevicaulis, fulvo-sericeus; foliis oblongis (lin. 4–6 longis); spicis oblongis; floribus mediocribus (lin. 8–9 longis) “albis seu violaceis” (ex Kunth); vexillo superne recurvo-patente; alis angustis rectis carinam subfalcatam longius superantibus; ovario sericeo suturis haud introflexis. — The specimens examined were collected near the city of Mexico, by Dr. Halstead (herb. Torr.), in flower. The legume is still unknown. Instead of the “alæ . . . nec adherentia” of Kunth, I find that the wing and keel petals on each side hook into each other neatly, as in other species.

A. ORTHANTHUS, sp. nov. Brevicaulis, velutino-tomentosus; foliis ovalibus (6–8 lin. longis); spicis capituliformibus; floribus elongatis (ultrapollicaribus); corolla ut videtur rubro-purpurea recta, vexillo spatulato conduplicato, alis lanceolatis carina haud incurva parum longioribus; legumine ovato tumido obcompressa coriaceo velutino sutura dorsali septifera fere bilocellato. — Mexico, near Perote, on sandy hillsides, Dr. Halstead, in herb. Torr. — Leaves and peduncles about 9 inches long. Immature legumes nearly an inch in length. The shape of the flower, with its narrow and strict petals, is remarkable.

turis utrisque sulcatis subdidymum. Ovarium etiam glaberrimum. — Plains of Nebraska to the western borders of Texas.

10. *A. BIGELOVII*, Gray, Pl. Wright. 2, p. 42. Legumen coriaceum, magis turgidum, ovali-oblongum (semipollicare), dense lanosum, suturis parum sulcatis. — Western borders of Texas, New Mexico, and near Chihuahua. — Nearly resembles the foregoing, except in the ovary and the legume.

§ 5. *Uliginosi*. Legumen coriaceum, turgidum, oblongum, teres, nec antice vix postice sulcatum, septo perfecto bilocellatum, fere rectum, estipitatum. — E radice perenni elati (sesqui-tripedales), pube adpressa subcinerei vel glabrati. Spicæ densifloræ. Flores viridulo-albidi vel ochroleuci, nunc purpureo lurido tincti, per anthesin patentissimi seu deflexi, sed legumina (semipollicaria) in spicam confertam arrecta. Stipulæ a petiolo liberæ, nunc discretæ, nunc in eadem stirpe adversus folium coadunatæ.

[*A. ULIGINOSUS*, L. Bracteis ovato-lanceolatis longe acuminatis calycem superantibus, et legumine postice longitudinaliter impresso (vix canaliculato) a *Canadensi* differt. — This Eastern Siberian species was recognized by Pallas as a form or analogue of the following.]

11. *A. CANADENSIS*, (Tourn.) L. *A. Carolinianus*, L. *A. orthocarpus*, Dougl. in herb. Hort. Soc. Elatus; bracteis subulatis calyce brevioribus; ovario glaberrimo; leguminis sutura dorsali haud impressa, ventrali prominente costæformi. — Canada and Saskatchewan to Louisiana and the interior of Oregon. Occurs with short and also with longer and slender calyx-teeth, the former chiefly eastward.

12. *A. MORTONI*, Nutt. in Jour. Acad. Philad. 7, p. 19. *A. spicatus* & (ex char.) *A. tristis*, Nutt. in Torr. & Gray, Fl. Minus altus; bracteis ovatis vel lanceolatis calyce brevioribus; ovario pubescente; legumine (*A. spicati*, Nutt.), pube tenui excepto, *A. Canadensi* similimo. — Rocky Mountains, Wyeth, Nuttall. Of *A. Mortoni* we have in herbaria only one or two incomplete flowering specimens; of *A. spicatus* a fruiting specimen, apparently of the same species. Except for the cinereous-pubescent ovary and legume I should refer them probably to *A. Canadensis*.

§ 6. *Onobrychides*. Legumen coriaceum, oblongum seu ovatum, rectum, sæpius pl. m. compresso- vel obcompresso-trigonum, semper postice sulcatum vel exaratum (sectione transversali obcordata vel e dorso biloba), sutura intrusa bilocellatum, pubescens, locellis

pluriovulatis. — Caulescentes e radice perenni, cinereo-pilosuli vel glabelli, adsurgentes vel decumbentes. Stipulæ adversus folium pl. m. coadunatæ. Spicæ seu capitula densifloræ. Flores mediores, sæpissime violacei seu purpureæ, semper leguminaque adscendentes vel arrecti.

13. *A. ADSURGENS*, Pall. Astrag. t. 31. *A. Laxmanni*, Jacq. Hort. Vind. 3, t. 37; Pall. Astrag. t. 30: forma pallidiflora. *A. striatus*, Nutt. in Torr. & Gray, Fl. 1, p. 330. Spithamæus ad sesquipedalem, pube adpressa minuta subcinereus, vel glabratus viridis; caulibus subvalidis; stipulis scariosis basi plerumque concretis; spica demum oblonga vel cylindracea; leguminibus ovato-oblongis haud stipitatis, pube brevi adpressa. — Plains of Nebraska to the interior of Oregon and throughout the Saskatchewan region. (Also Siberia.) The Russian botanists recognize a white-haired as well as dark-haired calyx in *A. adsurgens*. A white-haired form, with a rather shorter calyx-tube, a very dense spike, and more nearly erect and rigid stems, which abounds on the plains of Nebraska, is Hooker's var. *robustior* (*A. nitidus*, Dougl. ined.), and is *A. striatus*, Nutt., or rather Nuttall's specimens are intermediate between this and the laxer form, with longer and partly dark-haired calyx: this particularly well accords with Pallas's original figure and description.

14. *A. HYPOGLOTTIS*, L.; DC. Astrag. t. 14. *A. arenarius*, Pall. Astrag. t. 34. *A. dasyglottis*, Fisch. *A. goniatus*, Nutt. in Torr. & Gray, Fl. Humilis, gracilior, diffuso-procumbens, pube laxiore; stipulis subfoliaceis concretis; capitulo plurifloro; leguminibus ovato-trigonis albo-villosis brevissime stipitatis oligo-(2-8-)spermis. — Upper plains of Nebraska, Rocky Mountains, and northward. (Siberia, Europe.)

§ 7. *Reflexi*. Legumen crasso-coriaceum, estipitatum, ovato-trigonum, postice profundissime sulcatum (sulco angusto marginibus rugulosis), bilocellatum, sectione transversali obcordato-biloba, locellis 3-4-ovulatis. Carina corollæ falcata, sursum attenuata, vexillum angustum subæquans, alas sublonge superans! — Caules graciles e radice annua, piloso-pubescentes; foliolis emarginatis. Flores parvi, brevissime pedicellati, pauciusculi, subcapitati, albo-violacei, patentes: legumina deflexa.

15. *A. REFLEXUS*, Torr. & Gray, Fl. 1, p. 334. — Texas. Known only from Drummond's specimens, Buckley's *A. Brazoensis*, which I had too hastily referred here, being different. Flowers scarcely 3 lines

long. Legumes 4 lines long, glabrous, the pericarp thickened on the back each side of the deep groove.

§ 8. *Didymocarpi*. Legumen tenuiter coriaceum, obcompresso-didymum, transversim costato-rugosum vel reticulatum, septo angusto bilocellatum, maturitate in cocca dua intus rima hiascentia monodisperma (nunquam ultra biovulata) secedentia. Ovarium breviter stipitatum. — Caulescentes e radice annua, parvuli, parce pubescentes; stipulis discretis fere liberis; foliolis emarginatis. Spicæ breves densifloræ. Flores parvi, violacei, nunc fere albi, carina apice arcte inflexa. Legumina sæpissime deflexa.

16. *A. DIDYMOCARPUS*, Hook. & Arn. Bot. Beech. p. 334, t. 81. *A. Catalinensis* & *A. nigrescens* (§ *Microlobium*), Nutt. Pl. Gamb., in Jour. Acad. Philad. n. ser. 1, p. 152. Triuncialis ad pedalem; floribus sessilibus in capitulo vel spica demum cylindracea; legumine didymo parvo valde rugoso (cinereo-hirsutulo scabro vel demum glabro) in calyce brevissime stipitato, locellis uni-ovulatis semine solitario fere repletis. — California. Occurs under a variety of forms, of which Dr. Brewer, of the Geological Survey of that State, has recently collected an instructive series. Ovary truly stipitate; but the stipe of the legume is very short and occult.

17. *A. BRAZOENSIS*, Buckley in Proceed. Acad. Philad. Dec. 1861, p. 452. Annuus? spithamæus; floribus brevissime pedicellatis laxiusculis; legumine maturo valde obcompresso fere scutelliformi incurvo glabro transversim nervoso versus margines reticulato, stipite e calyce exserto, locellis biovulatis plerumque monospermis. — W. Texas, Buckley. Valley of the Nueces, Major G. H. Thomas, in herb. Torr. — In a notice of Mr. Buckley's Texan plants, contributed to the Proceedings of the Philadelphia Academy, April, 1862, I wrongly referred Mr. Buckley's very imperfect specimens of this plant to the little known *A. reflexus*, Torr. & Gray. But the good specimens, with mature fruit, which I now find in Dr. Torrey's herbarium, collected by Major Thomas, show that the species is wholly distinct, and is really allied to *A. didymocarpus*, as its propounder supposed. The disciform and somewhat acetabuliform legume is a quarter of an inch in diameter; its stipe about the length of the calyx.

§ 9. *Micranthi*. Legumen coriaceum, oblongum, lanceolatum, seu lineare, rectum vel curvatum, haud stipitatum, postice sulcatum, sutura dorsali intrusa ventralem extus prominulam attingente bi-

locellatum, locellis multiovulatis. — Caulescentes, humiles vel graciles e radice plerumque annua. Stipulæ discretæ fere liberæ. Flores parvi seu parvuli, violacea seu albida, carina apice incurva vel obtusissima; calycis tubo brevi. (Species inter se diversæ.)

- * Flores numerosi, dense spicati, per anthesin leguminaque deflexi: pedunculi elongati. Pedales et ultrapedales, strigoso-puberuli.

18. *A. VACCARUM*, Gray, Pl. Wright. 2, p. 43. Cinereo-puberulus; radice perenni; calycis dentibus tubo æquilongis; corolla incurva (alba seu albida nunc post anthesin purpurea); leguminibus lanceolato-oblongis arcuatis hirsutulis, sectione transversali late obcordata. — Arizona.

19. *A. HARTWEGI*, Benth. Pl. Hartw. p. 10; Torr. Bot. Mex. Bound. p. 56. Viridior; calycis dentibus tubo brevioribus; corolla fere recta. — Arizona and Mexico. — Legume unknown, but from the enlarging ovary apparently like that of *A. vaccarum*, which may pass into this.

- * * Flores pauciusculi in racemo laxo, per anthesin leguminaque penduli. Humiles, glabelli.

20. *A. COBRENSIS*, Gray, Pl. Wright. p. 43. Diffusus; foliolis retusis; pedicellis tubo calycis vix brevioribus; corolla purpurascens; leguminibus obcompressis oblongis rectis dorso late concavis sub-cymbæformibus. — New Mexico. Ovary short-stipitate, but the legume sessile in the calyx.

- * * * Flores pauci capitati, cum leguminibus oblongis erecti. Corolla dentes calycis tubo multo longiores subulato-lineares haud superans. Humiles e radice annua, villosa-hirsuti.

21. *A. WRIGHTII*, Gray, Pl. Lindh. 2, p. 176, & Pl. Wright. 1, p. 51. Legumen rectum, subcompressum, bicarinatum, acutum, calyce dimidio longius; stylo perbrevis. — Texas. — Very unlike any other of our species.

- * * * * Flores pauci subcapitati, nunc subsolitarii, parvuli, carina vexillo valde breviori apice inflexa paullo producta. Legumen lineare, subcompressum, dorso bicarinatum. Humiles e radice annua, diffusi; foliolis plerumque retusis.

22. *A. NUTTALLIANUS*, DC. Prodr. 2, p. 289. *A. micranthus*, Nutt., non Desv. Glabellus vel cinereo-pubescent; leguminibus juxta basin sursum incurvatis reticulatis aut glabris aut (var. *trichocarpus*,

etc.) cinereo-hirsutulis. — Arkansas and Texas to Arizona. Flowers varying from violet-purple to whitish.

23. *A. LEPTOCARPUS*, Torr. & Gray, Fl. 1, p. 334. Subglaber; leguminibus rectis patentibus minus reticulatis glabris. — Arkansas and Texas. — Corolla 4 or 5 lines long, curved, violet or violet-tipped, the keel produced into a narrower apex. Legume an inch long, thin-walled.

§ 10. *Succumbentes*. Legumen chartaceo-coriaceum, haud stipitatum, lineari-elongatum, valde compressum, sursum falcatum, dorso bica-rinatum sulco profundo, sutura intrusa ventralem extus prominu-lam acutam attingente bilocellatum, sectione transversali Y-formi. — Caules humiles, diffusi, flexuosi; pedunculis brevibus; stipulis discretis liberis. Flores majusculi, laxiuscule subcapitati, pur-purascentes; calyce cylindrico.

24. *A. SUCCUMBENS*, Dougl. in Hook. Fl. Bor.-Am. 1, p. 151. Cinereo-hirsutus; foliolis obovatis; leguminibus arrectis nitidis eximie reticulatis rete transversa. — Interior of Oregon, on barren grounds of the Columbia and Wallawallah. — Flowers narrow, three fourths of an inch long. Legumes from one to two inches long.

§ 11. *Galegiformes*. Legumen stipitatum e calyce exsertum, cum flore pendulum, coriaceo- vel cartilagineo-chartaceum, rectum, pl. m. trigonum, in nostris angustum, postice maxime sulcatum, sutura dorsali intrusa semi- vel fere bilocellatum. — Caules foliosissimi, e radice perenni erecti, validi, sulcati; stipulis discretis liberis. Racemi elongati confertiflori. Flores majusculi, albi vel ochro-leuci (carina tantum purpureo tineta).

* Calyx basi vix gibbosus, nigricanti-pilosus.

25. *A. DRUMMONDII*, Dougl. in Hook. Fl. Bor.-Am. 1, p. 153, t. 57. Molliter villosus, albiflorus; calycis dentibus subulatis tubo brevioribus; legumine glaberrimo lineari-elongato tereti-biventricoso, sulco angusto profundissimo, sectione transversali obcordato-biloba, stipite calycis dentes superante. — Saskatchewan or Hudson's Bay to Nebraska and the Rocky Mountains. — Legume completely or incompletely divided by the intrusion of the dorsal suture.

* * Calyx basi valde gibbosus.

26. *A. RACEMOSUS*, Pursh, Fl. 2, p. 740. *A. galegoides*, Nutt. Gen. Appresse pubescens, glabratus, albiflorus; calycis albido-pube-ruli dentibus setaceis tubo paullo brevioribus stipitem adæquantibus; legumine glaberrimo lanceolato-oblongo triquetro. — Plains of Nebraska

and Idaho to the Rocky Mountains. — Legume not divided internally into two cells, but the cross section somewhat equally triradiate or Y-shaped.

27. *A. CYRTOIDES*, sp. nov. Molliter pubescens; stipulis parvis; foliolis 7–10-jugis lineari-oblongis supra glabris; pedunculis folia longe superantibus; racemo spiciformi; floribus in pedicello brevi suberecto resupinato-pendulis; calycis tomentulosi dentibus subulatis tubo oblongo 3–4-plo brevioribus; corolla ut videtur ochroleuca calyce vix duplo longiore; ovario stipitato lineari cinereo-pubescente. — Clear Water River, interior of Oregon (now in Washington Territory), in rich land on hillsides, April 14, Rev. Mr. Spalding. — This we have long had in the herbarium; but the legume is still unknown. Its near relationship to *A. racemosus* is manifest. Its calyx is still more gibbous at the insertion and bossed on the upper side, like that of a *Cuphea*. Corolla from half to two thirds of an inch long, less exerted from the calyx than in allied species.

§ 12. *Ocreati*. Legumen estipitatum, coriaceum, obcompressum vel obcompresso-trigonum, sutura dorsali impressa ventrali approximata pl. m. interstinctum, haud bilocellatum. Humiles vel humifusi e radice perenni, pilis incumbentibus canescentes vel strigosi. Stipulæ a petiolo liberæ, inter se adversus folium alte connatæ. Flores spicati, vix mediocres; calycis tubo sæpius campanulato.

* Flores saturate flavi. Stipulæ in ocream obliquam petioli basin caulemque vaginantem coalitæ.

28. *A. FLAVUS*, Nutt. in Torr. & Gray, Fl. 1, p. 335. Multicaulis, diffusus, pube tenui canescens; foliolis linearibus subacutis; legumine parvo (4 lin. longo) calyce semi-incluso canescente ovato recto utrinsecus impresso, loculo suturis approximatis longitudinaliter strungulato. — Rocky Mountains, about lat. 41°; found only by Nuttall.

* * Flores purpurei, patentes. Stipulæ vix vaginantes.

29. *A. HUMISTRATUS*, Gray, Pl. Wright. 2, p. 43. Strigoso-pilosus, subglabratus; caulibus plurimis e radice perenni procumbentibus elongandis; foliolis lanceolatis seu lineari-oblongis acutis; calycis dentibus tubo longioribus; vexillo albo-purpureo et lineato; carina apice angustato producto inflexa; legumine oblongo-lineari arcuato pubescente obcompresso-trigono, sutura dorsali intrusa ventralem extus prominentem carinatum haud attingente. — New Mexico and Arizona.

* * * Flores majusculi ochroleuci? Stipulæ vix vaginantes.

30. *A. OREGANUS*, Nutt. l. c. Nanus, hirsutulo-canescens; foliolis obovatis emarginatis; floribus in pedunculo brevi spicato-capitato; calyce cylindraceo tubo dentibus bis longiori; ovario fere semi-bilocellato. — Western slope of the Rocky Mountains, collected only by Nuttall, without fruit. Arranged among ochroleucous species in the Flora of North America; but the color of the corolla is not recorded, nor can it be determined from the only specimen I have seen, that in herb. Torrey. The stipules, at least the lower ones, are connate almost to the top.

§ 13. *Microlobi*. Legumen minimum (lin. 2–3 longum), estipitatum, coriaceum seu cartilagineum, 6–7-ovulatum, elliptico-ovatum, aut fere teres postice vix complanatum, aut postice late concavum, semper uniloculare, sutura neutra introflexa, ventrali costiformi crassa extus prominente. — Subcineri: caules erecti vel adscendentes e radice perenni, graciles, rigiduli; foliolis 5–8-jugis linearibus. Stipulæ inferiores subconnatæ, cæteræ discretæ. Racemi spiciformes, multiflori, virgati. Flores parvi, purpurei, per anthesin recurvo-patentes; calyce brevi, dentibus abbreviatis.

Here are two closely allied species which have been confounded, and indeed are not readily distinguished without the fruit; one of which, by the strong concavity of the dorsal face of the legume, would be looked for in *Astragalus proper*, while the other, wanting this concavity, is referable to *Phaca*, where it would be sought among the *Scytocarpi*.

31. *A. GRACILIS*, Nutt. in Fras. Cat., & Gen. 2, p. 100. *A. parvifolius*, Nutt. in herb. Acad. Philad. *Dalea parviflora*, Pursh, Fl. 2, p. 474. Caulibus virgatis (ultrapedalibus e radice prælonga dulci); foliolis angustissime linearibus fere filiformibus obtusis retusisve (lin. 7–10 longis); racemis longe pedunculatis elongatis densifloris; floribus pallide purpureis albidisve (lin. 3 longis); leguminibus patentibus coriaceis dorso impresso quasi cymbiformibus canescenti-pilosis demum glabellis transversim rugoso-venosis, sutura ventrali subacuta. — Plains of Nebraska and Missouri to the Rocky Mountains. — This and the following species may have been confounded from the first. Except as to the fruit, Nuttall's original description would as well or better apply to *A. microlobus*; but the original specimens preserved are of the plant here retained as *A. gracilis*. From his tickets it appears that he more recently noticed that there were two species; but the fruit of the second species, which confirms the distinc-

tion, was first brought to light in Hall and Harbour's recent collection, no. 119.

32. *A. MICROLOBUS*. *A. gracilis*, Torr. in Ann. Lyc. New York, 2, p. 179; Nutt. in herb. Acad. & herb. Torr. 1838; Gray in coll. Parry, no. 189, & coll. Hall & Harbour, no. 119. Caulibus subpedalibus diffusis; foliolis linearibus seu oblongo-linearibus emarginatis (lin. 4-6 longis); racemis breviusculis sæpius laxifloris; floribus saturate purpureis (lin. 4 longis); leguminibus reflexis crasso-cartilagineis puberulis tenuiter rugulosis turgidis, dorso tantum planiusculo, sutura ventrali percrasso. — Plains of Nebraska, &c., to the Rocky Mountains. — By the above characters flowering specimens of this may be distinguished from the original *A. gracilis*; and the species is confirmed by the legume, which is that of a *Phaca*, and in texture, &c. is much like that of *A. pectinatus* on a very reduced scale.

§ 14. *Oroboidei*. Legumen stipitatum vel estipitatum, coriaceum vel fere membranaceum, vix aut ne vix obcompressum, sutura dorsali nunc paullulum nunc profundius impressa vel introflexa plane uniloculare vel imperfecte bilocellatum. — Caulescentes, glabelli vel pubescentes, graciles. Stipulæ præter infimas discretæ, fere liberæ. Racemi sæpe spiciformes breves, vel capitula pauciflora. Flores parvuli vel mediocres, albo-violacei, purpurei seu albi, patentes; calyce brevi.

* *Veri*, *Boreales*, e radice perenni adscendentes; floribus pedicellatis plerumque racemosis. Legumina oblonga, stipitata (in *A. Oroboide* et *sparsiflora* stipite brevissimo occulto), subsecunda, sæpius pendula, sutura ventrali extus prominula.

+ Legumen membranaceum, glabrum vel tenuiter puberulum, lateraliter compressiusculum, septo e sutura dorsali rudimentario angustissimo uniloculare, ventre gibbosum, nempe sutura dorsali recta vel concaviuscula, ventrali arcuata.

++ Legumen longe stipitatum, dorso nequaquam sulcatum, sectione transversali ovali. Foliola nunquam retusa, infima stipulis approximata, nisi foliorum inferiorum. Flores in racemo compacto, albi vel cærulescentes, carina violacea.

33. *A. ABORIGINUM*, Richards. in App. Frankl. Journ. ed. 2, sub nom. falso "*aboriginorum*." *Phaca aboriginorum*, Hook. Fl. Bor.-Am. 1, p. 143, t. 56. Canescenti-puberulus seu villosulus; caulibus adscendentibus pedalibus rigidis; foliolis 3-6-jugis linearibus seu oblongo-

lanceolatis; calycis dentibus filiformi-subulatis tubo parum brevioribus; leguminibus semi-ellipticis mox glabris, stipite calycem bis excedente. — Lake Winipeg to Bear Lake and the Rocky Mountains. — The legume is correctly described by Hooker as “sutura hinc plana marginibus paululum introflexis, illinc curvata”; but in the plate the straight suture is represented as the seminiferous one. Hence the erroneous description in this respect in the Flora of North America.

34. *A. GLABRIUSCULUS*, Gray, Enum. Pl. Parry, Hall & Harbour, no. 116, in Proceed. Acad. Philad. March, 1863. *Phaca glabriuscula*, Hook. l. c. Glaber, vel pilis brevibus raris conspersus; foliolis tenuioribus viridibus “lineari-lanceolatis subacutis” seu oblongis utrinque obtusis; ovario glaberrimo; leguminibus lanceolato-subfalcatis in stipitem calyce bis terve longiorem attenuatis: cæt. fere præcedentis. — Valleys in the Rocky Mountains in British America, Drummond. Also, var. *major*, near lat. 40°, at middle elevation, Hall and Harbour; with foliage resembling large forms of *A. alpinus*. Legume an inch, stipe nearly half an inch long.

++ ++ Legumen brevi-stipitatum, dorso haud vel obsoletissime sulcatum, sectione transversali obovata retusa, pube minuta subnigricante. Foliola subretusa. Flores albi, parvuli (lin. 4. longi).

35. *A. ROBBINSII*, Gray, Man. Bot. N. U. S. ed. 2, p. 98. *Phaca Robbinsii*, Oakes in Hovey, Mag. Hort. 7, p. 181. Subglaber; caulibus pedibus suberectis; foliolis 3–5-jugis ovalibus oblongisve; racemo compacto oblongo; dentibus calycis tubo multo brevioribus; leguminibus tenuiter membranaceis oblongis rectis vel subincurvis parvulis (semipollicaribus) obtusissimis basi in stipitem e calyce haud exsertum subito angustatis. — Near Burlington, Vermont, in fissures of limestone banks of the Onion or Winooski River; the only known habitat, discovered by Dr. Robbins. In this, as in the two preceding species, the dorsal suture is not itself introflexed, but bears the rudiment of a septum in the form of a narrow and thin membrane projecting distinctly, but a very little way, into the cell. The present is a connecting link between the foregoing and the following species.

+ + Legumen magis coriaceum, nigro-rariusve cinereo-pubescent, sutura dorsali sulcato-impressa pl. m. trigonum et semi-bilocellatum, —

++ Subsymmetricum, breve, lentiformi-oblongum, compressiusculum, sectione transversali obcordata, sutura ventrali paullo magis gibbosa.

36. *A. OROBOIDES*, Hornem. Fl. Dan. t. 1396. *A. leontinus*, Wahl. Fl. Lapp. t. 12, f. 4. *A. alpinus giganteus*, Pall. Astrag. t. 33. *A. brachytropis*, C. A. Meyer. *Phaca brachytropis* (Stev.) & *oroboides*, DC. *P. parviflora*, Nutt. in Torr. & Gray, Fl. Glabellus; caulibus suberectis sub-sesquipedalibus; foliolis 5-7-jugis oblongis ovalibusque vix retusis; racemo elongato secundo; floribus violaceis aut purpureis (lin. 5-6-longis), alis carinam superantibus; legumine elliptico-lentiformi semipollicari sæpissime nigro-villoso calyce triplo longiore dorso modice sulcato subsemibilocellato oligospermo, stipite brevissime occulto. — Arctic and North Alpine Europe and Asia.

Var. AMERICANUS. *Phaca elegans*, Hook. l. c. Minus viridis, pube tenui subcinereus; foliolis sæpe lineari-oblongis; floribus semper minoribus (lin. 3-4 longis); legumine calycem 3-4-plo superante minus nigricante pube appressa sæpius griseo. — Rocky Mountains, in and considerably below the Alpine region, Drummond, Parry and Hall. Saskatchewan, Bourgeau. Labrador, Elsner, communicated by the late Dr. Steetz. — Legume 5 to 6 lines long.

++ ++ Legumen dorso magis impresso trigonum, sectione transversali profunde obcordata, rectiusculum vel incurvum, dorso gibbosum, nempe sutura dorsali longiori convexa, ventrali recta seu concava. Foliola nunc retusa vel subemarginata.

37. *A. ALPINUS*, L.; Pall. Astral. t. 32. *A. secundus*, Michx.! *A. Labradoricus* & *Phaca astragalina*, DC. Piloso-pubescent seu glabellus; caulibus diffusis; foliolis 6-12-jugis ovalibus seu oblongis; racemo brevi vel subcapitato plurifloro; floribus violaceis seu albo-violaceis (lin. 5-6 longis), alis carinam majusculam raro vel paullo superantibus; legumine oblongo recto vel subcurvato nigro-villoso seu nigro-pubescente trigono-turgido sutura profunde intrusa semi- vel subbilocellato, stipite calycem sæpius excedente. — Arctic and Alpine regions around the Northern hemisphere. Not found on the higher mountains of the Eastern United States, but occurring at moderate elevations in the northern parts of Vermont and Maine, and even on the coast of Maine.

38. *A. SPARSIFLORUS*. Gray in Enum. coll. Parry, Hall, & Harbour, l. c. no. 128, 129, sine char. Appresse pilosulus, glabratus; caulibus gracillimis ramosis diffusis; stipulis triangulari-subulatis discretis; foliolis 4-6-jugis obovatis vel suborbiculatis sæpe emarginatis parvis (2-3 lin. longis); pedunculis folio vix longioribus 3-5-floris; floribus

albis violaceo tinctis parvis (lin. 3 longis), vexillo apice emarginato-bifido alisque carinam incurvum longe superantibus; calycis dentibus tubo æquilongis; ovario 8-10-ovulato breviter stipitato; legumine parvo oblongo falcato-incurvo striguloso-pubescente substipitato oligospermo sutura dorsali intrusa semibilocellato. — On the lower Rocky Mountains of Colorado Territory, about lat. 40°, Hall and Harbour, no. 128. — Stems a foot or more in length, with many slender branches. Legumes 3 to 4 lines long, coriaceous, spotted with purplish, either slightly or strongly incurved, pointed with the style, pubescent with whitish short hairs, ripening from three to five seeds; the stipe as short and occult as in *A. oroboides*; the dorsal suture as deeply sulcate-impressed as in that species; the ventral suture acute and prominent.

Var. MAJUSCULUS. Glabrior; foliis majoribus (lin. 3-5) obovato-oblongis; pedunculis 5-10-floris in racemo laxo secundo; legumine magis elongato semipollicari 10-12-spermo. — With the preceding (no. 129 of the same collection); the legumes the same, except in their greater length, similarly spotted.

* * *Californici*, pusilli, e radice annua erecti; foliis obcordato-emarginatis; floribus paucis capitatis. Corollæ alæ et præcipue vexillum carinam longe superantes. Ovaria sericeo-canescencia breviter stipitata vel sessilia. Legumina matura ignota.

39. *A. TENER*, sp. nov. *Phaca astragalina* β. Hook. & Arn. Bot. Beech. p. 334. *A. Hypoglottis*, var. *strigosa*, Kellogg in Proceed. Calif. Acad. 2, p. 115, fig. 373. Spithamæus, pilis nigris albidisque brevissimis strigosus; stipulis parvis ovatis scariosis; foliis 5-7-jugis lineari-cuneatis late emarginatis; ovario lineari semibilocellato 10-12-ovulato stipitato, deflorato reflexo. — California, Douglas: from near Monterey or San Francisco. — This was long ago collected by Douglas, without fruit. But the forming legume is deflexed, linear-lanceolate, canescent, and on a stipe considerably shorter than the tube of the calyx. The latter is black-hairy and in other respects much like that of *A. alpinus*. But the corolla is wholly different, much narrower, with the far smaller keel one third shorter than the wings, and only half the length of the standard; the color apparently similar, the keel tipped with deep violet. The root is evidently annual. If this is, as I suppose, the plant coarsely figured by Dr. Kellogg, the legumes are oblong-linear, somewhat incurved, not obviously stipitate, and only spreading.

40. *A. BREWERI*, sp. nov., Gray in Proceed. Acad. Calif. ined. Subspithamæus; foliolis 4–5-jugis oblongo-obcordatis; capitulo 5–7-floro compactiore; legumine immaturo globoso-ovato cano-sericeo in calyce haud stipitato erecto 6-ovulato uniloculari, sutura dorsali leviter intrusa; cæt. præcedentis. — California, “in the Sonoma valley, common in fields: April 18.” Dr. W. H. Brewer, California Geological Survey. — Closely resembling the foregoing in its whole appearance; but perhaps more branched from the annual root, and with broader leaflets. Calyx and corolla similar; the latter tinged with violet-purple, and the summit of the keel deep violet. But even the ovary is sessile and ovate, and the half-grown legumes (which are very white-hairy and only twice the length of the calyx) are erect, and in a close head.

* * * *Austro-Orientales*; racemis spiciformibus sæpissime brevibus; calyce nunquam nigro-piloso. Legumina glaberrima, reticulata, haud vixve stipitata, oblonga, pl. m. incurva.

+ E radice annua multicaulis, diffusus.

41. *A. LINDHEIMERI*, Engelm. in Gray, Pl. Wright. 1, p. 52. Glabellus; foliolis 6–8-jugis angusto-oblongis plerumque emarginatis; racemo subcapitato; calycis dentibus subulato-setaceis tubo subduplo longioribus; corolla violacea; carina majuscula alis et vexillo amplo vix emarginato paullo brevior; leguminibus in pedicello patente adsurgentibus oblongo-linearibus subfalcatis compressis transversim venuloso-reticulatis dorso bicarinatis sutura intrusa semibilocellatis, sutura ventrali costiformi acuta. — Texas. — Corolla half an inch long, showy. Legume an inch or more in length, substipitate, the ovary manifestly short-stipitate.

+ + E radice perenni.

42. *A. DISTORTUS*, Torr. & Gray, Fl. 1, p. 332. Multicaulis, humilis, diffusus, subglaber; foliolis 8–12-jugis oblongis emarginatis; floribus breviter spicatis; calycis dentibus lato-subulatis tubo (nigrescenti-puberulo) dimidio brevioribus; corolla pallide purpurea, vexillo alte emarginato; leguminibus ovato-seu lanceolato-oblongis arcuatis crassocoriaceis minutim reticulatis subteretibus ad suturas præsertim dorsali sulcatis unilocularibus. — Texas, Arkansas, and S. Illinois (Dr. Mead). — Corolla narrow and small, scarcely over four lines long. Legumes variable in thickness, delicately reticulated when mature, 6 to 9 lines long, obscurely obcompressed; the ventral suture a little, but the dorsal more conspicuously introflexed.

43. *A. OBCORDATUS*, Ell. Sk. 2, p. 227. Multicaulis, humilis, diffusus, subglaber; foliolis 7-12-jugis obcordatis; racemo brevi spiciformi; calycis cinereo-pilosi dentibus setaceo-subulatis tubo æquilongis; corolla pallide purpurea, vexillo emarginato; leguminibus lunatis subcompressis tenuiter coriaceis maxime reticulatis, sutura dorsali extus sulcata intra loculum leviter intrusa, ventrali acuta costiformi. — Florida and Georgia, in sand-barrens. — Flowers scarcely larger than in the foregoing; the crescent-shaped legumes larger, fully an inch long, the ventral suture salient.

44. *A. GLABER*, Michx. Fl. 2, p. 66. Elatus (bipedalis), erectus; foliolis 9-18-jugis elliptico- seu lineari-oblongis crassiusculis vix retusis; stipulis minimis; racemo laxifloro; calycis dentibus triangulari-subulatis brevibus; corolla alba, carina alis vexilloque paullo brevior; leguminibus oblongo-linearibus arcuatis seu rectiusculis subcompressis transversim venoso-reticulatis dorso sulcatis et sutura introflexa semibilocellatis, sutura ventrali extus prominente costiformi. — North Carolina to Florida, in pine-barrens. — Flowers fully half an inch, legumes an inch long.

§ 15. *Lotiflori*. Orobideis Austro-Orientalibus subdiv. + + fere similes, nisi plantæ et legumina villosæ seu canescentes, humiliores, floribus flavidis. Legumen semi-ovatum oblongumve, turgidum, coriaceum, subarcuatum, dorso gibboso pl. m. impresso subtrigonum, uniloculare, sutura ventrali extus carinato-prominente. Corolla calycem paullo superans, carina apice inflexa. Calycis dentibus elongatis tubo longioribus.

45. *A. VILLOSUS*, Michx. Fl. 2, p. 67. *Phaca villosa*, Nutt. etc. Laxe villosus; caulibus spithamæis adsurgentibus; foliolis ovalibus retusis; racemis longe pedunculatis capituliformibus plurifloris; calycis dentibus lineari-subulatis tubo multum longioribus; legumine villosissimo dorso manifeste intruso fere semidiviso, sectione transversali obcordata. — Dry pine barrens, South Carolina to Florida and Louisiana. — Corolla 4 lines long, curved.

46. *A. LOTIFLORUS*, Hook. Fl. Bor.-Am. l. c. *Phaca lotiflora*, Nutt.; Torr. & Gray, l. c. *P. (Astragalus) cretacea*, Buckley in Proceed. Acad. Philad. Dec. 1861, p. 452. Pilis appressis canescens vel cinereus; caulibus brevissimis; foliolis lanceolato-oblongis; capitulis paucifloris; calycis dentibus subulatis tubo longioribus; legumine oblongo-ovato magis inflato subcanescente dorso leviter impresso, sectione transversali obovata retusa sæpiusve basin versus late obcordata. —

Formæ duæ: α . PEDUNCULOSUS, normalis, pedunculis folia subæquantibus vel superantibus: β . BRACHYPUS, pedunculis brevissimis vel subnullis. — Plains of Texas and Nebraska to the Rocky Mountains and Hudson's Bay. Both forms are represented in Hall and Harbour's collection, no. 131. The form β , from the withered corolla being carried up on the apex of the growing legume, is perhaps precociously fertilized. It seems doubtful if the root is perennial. Mature legumes about an inch long; when fresh or when dried without pressure the impression of the back of the legume is manifest enough, although shallower than in *A. villosus*, which is a true *Astragalus*; while this would be taken for a *Phaca*.

§ 16. *Argophylli*. Legumen estipitatum (plerumque crasso-coriaceum et obcompressum), sutura dorsali impressa vel intrusa ventrali approximata pl. m. interstinctum, haud septato-bilocellatum, pubescens. — Humiles, albo-sericei vel canescentes. Stipulæ discretæ, fere liberæ. Flores spicati vel subcapitati, violacei vel purpurascens. Calycis dentibus tubo sæpius oblongo vel cylindrico brevioribus.

* Multicaulis e radice annua vel bienni; floribus parvulis albo-purpurascens. Legumen inflatum, membranaceum, incurvum.

47. *A. PUBENTISSIMUS*, Torr. & Gray, Fl. 1, p. 693. *A. multicaulis*, Nutt. l. c., non Ledeb. Nanus, pube laxa hirsuto-canescens; foliolis oblongis obovatisve; floribus in pedunculo brevi paucis subracemosis; calycis dentibus tubo campanulato æquilongis; legumine villosa membranaceo inflato ovato-lunato valde incurvo dorso sulcato sutura leviter inflexa uniloculari. — Colorado Territory, near the sources of the Colorado of the West; found only by Nuttall. Legumes 9 or 10 lines long, the ventral suture perhaps slightly, the dorsal more deeply sulcate-introflexed.

* * Simpliciter caulescens e radice annua; floribus mediocribus violaceis. Legumen rectum?

48. *A. ARTHU-SCHOTTII*, sp. nov. Pube appressa sericea undique incanus; caule (spithamæo et ultra) erecto; foliolis 4-9-jugis obovatis sæpe retusis, pagina superiore interdum glabrata; floribus in pedunculo folium superante pluribus laxè spicatis; calycis dentibus subulatis tubo oblongo-campanulato vix dimidio brevioribus; carina majuscula subrecta vexillo paullo brevior; legumine juvenili oblongo-lanceolato acuminato recto canescente e sutura dorsali semiseptato. —

Interior district between Utah and California; on the Mohave River, April 23, Fremont. Diluvial banks of the Colorado near its mouth, March 12, A. Schott. Boca Grande, Capt. E. K. Smith. — Specimens of this have accumulated enough to show that they belong to a quite distinct species, although only the forming fruit has come to hand. It was unnoticed in the Botany of the Mexican Boundary Survey.

* * * *Brevicaules* vel *subcaulescentes*, sæpiusque *depresso-humifusi* vel *cæspitantes* e radice longa perenni; floribus majusculis breviter pedicellatis plerumque violaceis; foliolis oblongis ellipticis obovatisve. Legumen crasso-coriaceum, maturum obcompressum vel obcompressotrigonum transverse rugulosum. (*Argophylli genuini*.)

The immature legumes in dried specimens frequently appear as if compressed (i. e. flattened parallel with the valves); but when fully mature I believe they are always obcompressed (i. e. contrary to the valves), or, by the salience of the ventral suture and introflexion of the dorsal one, obcompressed-triangular.

49. *A. MISSOURIENSIS*, Nutt. Gen. 2, p. 99. *A. melanocarpus*, Fraser, Cat.; Richards. in Frankl. Journ.; Hook., etc. *Subcaulescens*, pube brevi appressissima cano-sericeus; pedunculis scapiformibus capitato-paucifloris vel spicato-8-14-floris; calycis dentibus tubo cylindrico vel cylindræco subdimidio brevioribus; corolla læte violacea (fide Nutt. raro alba); legumine fere recto (circiter pollicari) nigricante elliptico. — Nebraska and New Mexico to the Saskatchewan. — The short and appressed pubescence of the calyx and of the legume is usually of blackish and whitish hairs intermixed. The mature legumes, when preserved in their natural form, or restored by maceration, are obcompressed, oftener so that the dorsal suture touches the ventral, which, however, is externally salient or carinate. But in herbaria, they frequently appear as if laterally compressed, with the dorsal suture only slightly intrusive.

50. *A. SHORTIANUS*, Nutt. in Torr. & Gray, Fl. 1, p. 331, ex descr. *A. humilis*, Geyer ex Hook. in Lond. Jour. Bot. 6, p. 211, non Bieb. *A. cyaneus*, Gray, Enum. coll. Parry, Hall, & Harbour, no. 126. *Subcaulis*, pube appressissima sericeo-canescens; foliolis majusculis (lin. 7-10 longis) obovatis ovatisve; pedunculis scapiformibus pauciplurifloris foliis sæpius brevioribus; calyce cylindrico (semipollicari), dentibus tubo dimidio brevioribus; corolla violacea vel cyanea; legumine immaturo ovato-lanceolato crasso (sesqui-bipollicari) puberulo

arcuato-incurvo. — Rocky Mountains, about the head-waters of the Platte or Nebraska.

Var.? MINOR. *A. cyaneus*, Gray, Pl. Fendl. p. 34 (magna pro parte). Sæpe subcaulescens; foliis minoribus; legumine oblongo- seu lanceolato-lineari arcuato-incurvo postice profunde sulcato-introflexo. — Mountains and plains, from the southern frontier of New Mexico and W. Texas to Nebraska and the Rocky Mountains. — Probably only a smaller form of *A. Shortianus*, between that and *A. Missouriensis*, which it closely resembles (except in the fruit and in usually wanting dark hairs), and with which I have more than once confounded it. In fruit it is distinguished from that species by its long ($1\frac{1}{2}$ inches or more), pointed, and strongly arcuate legume. Its cross-section is obcordate-two-lobed, the intruded dorsal approaching the externally carinate ventral suture.

51. *A. PARRYI*, Gray, Enum. coll. Parry, in Sill. Jour. n. ser. 33, p. 410, & Enum. coll. Parry, Hall, & Harbour, in Proceed. Acad. Philad. March, 1863, p. 60. Brevicaulis, cæspitoso-humifusus, pilis laxis patentibus villosus; pedunculis breviusculis 6 – 10-floris; floribus laxè subcapitatis; calycis dentibus tubum oblongum subæquantibus; corolla albida seu flavidula (lin. 6 – 8 longa), carina apice purpurascens; legumine pubescente oblongo-lanceolato, maturo arcuatim incurvo demumve circinato valde obcompresso tam antice quam postice sulcato-impresso et propter suturas contiguas fere bilocellato. — Rocky Mountains, both low and subalpine, in Colorado Territory, and south to the Llano Estacado in N. W. Texas. I find in Dr. Torrey's herbarium a specimen collected by Fremont in his second expedition (station not recorded), with very ripe legumes: these are an inch or rather more in length, strongly rugulose, much obcompressed, and curved nearly into a ring. In Dr. Parry's specimens they are much less incurved and less rigid.

52. *A. GLAREOSUS*, Dougl. in Hook. Fl. Bor.-Am. 1, p. 152. *A. argophyllus*, Nutt. in Torr. & Gray, Fl. l. c. excl. syn. Cæspitoso-depressus, pilis incumbens albidis villososericeus; pedunculis 3 – 6-floris folia haud superantibus; floribus angustis (lin. 9 – 12 longis); calycis dentibus tubo longe cylindrico triplo brevioribus; corolla læte violacea; legumine immaturo oblongo-ovato apice attenuato incurvo sericeo-pubescente, "maturo subglabro." — Dry gravelly banks of streams, in and near the Rocky Mountains, on the southern tributaries of the Columbia River, and of the Platte. In the herbarium, without

fruit, it is liable to be confounded with the two succeeding species, but its pubescence is hirsute-silky or villous-silky, not lanuginous; and the forming legume is canescent with short appressed pubescence.

Series II. Legumen sutura neutra introflexa plane uniloculare, aut sutura ventrali magis quam dorsalis intrusa. PHACA, L., DC.

1. Folia pinnato-plurifoliolata, rarius paucifoliolata vel abortu defoliolata, in nonnullis *Homalobis* simplicia.

§ 17. *Eriocarpi*. Legumen lanosissimum, plerumque sub lana longa copiosissima occultum, breve, turgidum, coriaceum, pl. m. incurvum, acuminatum vel apiculatum, estipitatum. — Brevicaules e radice valida perenni, humifuso-cæspitantes, mollissime lanuginosi. Flores elongati, sæpius pollicares, laxè subcapitati; calyce longe cylindrico.

53. *A. inflexus*, Dougl. in Hook. Fl. Bor.-Am. 1, p. 151. Lanugine laxa subvillosa cinereo-canescens; caulibus (6–12-pollicaribus) diffuso-procumbentibus; foliolis oblongis; floribus læte purpureis, carina dentes calycis graciles setaceos laxos paullo superante; legumine ovato-oblongo, juniore lanosissimo, maturo (in herb. Hook.) subdenudato maxime incurvo obcompresso suturis utrisque præsertim ventrali impressis longitudinaliter interstincto. — Barren grounds along the southern tributaries of the Columbia River; on the Clearwater, Rev. Mr. Spalding, &c. — Flowers fully an inch long, evidently purple or violet and showy. — This species, copiously collected by Mr. Spalding, with only forming fruit, I have variously confounded with the preceding on account of its purple flowers, and with the following on account of the woollier pubescence and the very woolly young pods. But on now comparing these materials with the description of *A. inflexus* by Sir William Hooker, and with a ripe pod from his herbarium, I think they may be united. From the mature legume it might as well be referred to the foregoing group; but here it is clearly the ventral suture which is intruded to meet the slightly impressed dorsal suture.

54. *A. PURSHII*, Dougl. in Hook. Fl. Bor.-Am. 1, p. 152. *Phaca mollissima*, Nutt. in Torr. & Gray, Fl. 1, p. 350. Lanugine laxa subvillosa cinereo-canescens, subacaulis vel humifuso-depressus; foliolis oblongis; floribus ochroleucis, carina apice purpurea dentibus calycis subulatis longius superante: legumine ovato (subpollicari) leviter incurvo, intus haud interstincto, lana persistente flavida. — Western side of the Rocky Mountains, through Utah and the interior of Oregon to the

mountains of California. — Flowers more or less smaller, and calyx-teeth much shorter and less attenuated than in the preceding.

55. *A. UTAHENSIS*, Torr. & Gray, Bot. coll. Gunnison & Beckwith, Pacif. R. R. Exped. 2, p. 120. *Phaca mollissima* β . *Utahensis*, Torr. in Stansbury, Rep. p. 385, t. 2. Lanugine implexa niveo-tomentosus, humifuso-caespitans; foliolis obovatis seu orbiculatis; floribus violaceis; legumine oblongo leviter obcompresso modice incurvo, cæt. fere præcedentis. — Utah, on the shores of Great Salt Lake. — Flowers rather shorter, but otherwise as large as those of *A. inflexus*; the calyx-teeth rather as in *A. Purshii*; the pubescence, &c. peculiar. On stripping off the wool from the pods, they are seen to be not unlike those of *A. inflexus*, except that they are less curved, and only a little sulcate at the sutures, which do not meet to divide the cell.

§ 18. *Oocarpia*. Legumen chartaceo-coriaceum, ovatum, vesicario-inflatum, estipitatum, glabrum, sutura dorsali obsolete ventrali manifeste intrusa. — Glabrati, e radice perenni erecti, foliosi; stipulis discretis liberis; foliolis oblongis ovalibusque nunc retusis. Flores in racemo spiciformi plures albi seu albidii, semipollicares; calyce brevi. Legumina erecta, nec ultrapollicaria.

56. *A. COOPERI*, Gray, Man. Bot. N. U. S. ed. 2, p. 98. *Phaca neglecta*, Torr. & Gray, Fl. 1, p. 344. Ultrapedalis, foliosus; foliolis oblongis; floribus confertis mox reflexis albis; calyce nigricanti-pubescente, dentibus subulatis tubo brevioribus; legumine ovato-globoso sub-obcompresso antice posticeque leviter sulcato, sutura dorsali intus prominula, ventrali satis introflexa. — W. New York to Wisconsin along the Great Lakes. Legume lined with cobwebby hairs which traverse the cell.

57. *A. OOCARPUS*. *A. Crotalariae* (in tab. *crotalarioides*), Torr. Bot. Mex. Bound. p. 56, t. 17, non *Phaca Crotalariae*, Benth. Elatus (4–6-pedalis); foliolis ovalibus parvulis crassiusculis; floribus patentibus in racemo sublaxo; calycis albido-puberuli dentibus brevissimis; legumine oblongo-ovato acuto antice solum leviter sulcato sectione transversa circulari, sutura dorsali intus vix prominula, ventrali introflexa. — Mountains east of San Diego, California, Dr. Parry. — Legume rather firmly coriaceous, with a somewhat lateral or oblique contracted insertion, within glabrous.

§ 19. *Inflatii*. Legumen membranaceum, vesicario-inflatum, globosum, oviforme, vel semi-ovatum, sæpius magnum, tenuiter reticulatum,

glabrum vel glabratum, sutura aut neutra aut rarius ventrali solum intus subintroflexa.

- * *Radix annua*. Legumen haud stipitatum, haud maculoso-pictum. Flores parvi, ochroleuci vel purpurascentes. — Humiles: foliola linearia seu lineari-oblonga, striguloso-cinerea.

58. *A. TRIFLORUS*, Gray, Pl. Wright. 2, p. 45. *Phaca triflora*, DC. Astrag. t. 1? *P. Candolliana*, H.B.K. Nov. Gen. & Sp. 6, p. 495, t. 586. A basi ramosissimus; floribus in pedunculo 3–15 ochroleuco-purpurascentibus; legumine ovali obtuso vel acutiusculo (7–12 lin. longo). — Arizona and Mexico. Legumes larger and more inflated in specimens from the northern stations, otherwise like the Mexican specimens. The specific name not appropriate.

59. *A. GEYERI*. *Phaca annua*, Geyer in Hook. Lond. Jour. Bot. 6, p. 213. Simplicior; floribus in pedunculo paucis luteo-albis; legumine ovato-lunato acumine incurvo (lin. 8–9 longo). — Drift-sand plains of the Upper Platte, Geyer. Said also to have been collected by Douglas and by Gordon. The crescentic outline and sharp acumination of the legume distinguishes this from the last. The leaflets are linear. There is an obscure *A. annuus*.

- * * *Radix filiformis*, aut annua? aut perennis (in *A. Hookerianus* adhuc ignota). Legumen maculosum, in albido seu viridulo purpureo-pictum, stipite brevi calycem adæquante sustentum. Flores in pedunculo pauci, parvuli, albo-rosei seu pallidi; carina apice inflexo subproducto.

60. *A. PICTUS*. *Phaca longifolia*, Torr. & Gray, Fl. & *P. picta*, Gray. Pube sericeo-strigulosa canescens, arenicolus; radice tenuissima (ut videtur nunc annua, nunc forte perenni surculos filiformes subterraneos proferente); stipulis subulatis rigidis persistentibus adversus folium basi connatis; foliolis anguste linearibus seu filiformibus, plerisque sæpius abortivis petiolo persistente folium filiforme mentiente; legumine pendulo ovoideo vix apiculato. — Nebraska and New Mexico, in drift-sand, "binding the sand-hills with its long filiform roots." — The name *filifolius*, which I had applied to one form of this species (see below) on remanding it to the genus *Astragalus*, is preoccupied by Clos in the Flora Chilena. That of *pictus*, so appropriate for the legume, may be adopted; for "*A. pictus*, Steud." is merely a name to replace "*A. bicolor*, Desf. Cat. addend.," of which no character was ever published, which has been overlooked in the Flora Chilena, and is

doubtless a synonyme of some described Chilian species. The following two forms are pretty clearly of one species.

Var. FOLIOLOSUS. *Phaca picta*, Gray, Pl. Fendl. p. 37. Folia perfecta; foliolis 3-7-jugis plerisque semipollicaribus; legumine parvulo vix ultra semipollicari.

Var. FILIFOLIUS. *Psoralea longifolia*, Pursh. Fl. 2, p. 741. *Orobis longifolius*, Nutt. Gen. 2, p. 95. *Phaca longifolia*, Torr. & Gray, Fl. 1, p. 346. *Astragalus filifolius*, Gray, in Pacif. R. R. Surv. 12, pars 2, Bot. t. 1, A. Folia sæpius imperfecta; foliolis perpaucis plerumque attenuatis (1-1½ poll. longis), terminali seu rhachi filiformi producto persistente; legumine 1-1½-pollicari.

61. A. HOOKERIANUS. *Phaca Hookeriana*, Torr. & Gray, Fl. 1, p. 693. Sericeo-pubescent, humilis (spithamæus); radice verosimiliter perenni; stipulis subscariosis discretis; foliolis lineari-oblongis subcuneatis 7-9-jugis; legumine erecto magno (bipollicari) oblongo-obovato apice rotundato basi in stipitem brevem attenuato. — Interior of Oregon, Douglas; station unknown. Legume beautifully mottled. Species somewhat like *P. arenaria*, Pall.

* * * Radix perennis. Legumen unicolor (haud maculoso-pictum).

+ Subacaulis, pauciflorus; legumen brevissime stipitatum.

62. A. MEGACARPUS. *Phaca megacarpa*, Nutt. in Torr. & Gray, Fl. 1, p. 343. Glabellus; foliolis 4-6-jugis late ovalibus ovatisve sæpius emarginatis; scapo 3-6-floro foliis multo brevioribus; floribus pollicaribus ochroleucis albidisve; calycis cylindracei dentibus subulatis elongatis carina paullo brevioribus; legumine ovato-oblongo acuminato 2-2½-pollicari basi obtusissimo stipite calyce multoties brevioris inserto erecto. — Plains of the Rocky Mountains; found only by Nuttall. No other North American species resembles it.

+ + Caulescentes, sat alti, foliosi; foliolis multijugis oblongis vel sublinearibus; racemis spicisve plerumque plurifloris. Præter *A. frigidum* Californici.

++ Legumen nunquam stipitatum, ultrapollicare, sæpius 1½-2-pollicare, sutura ventrali recta vel convexiuscula, dorsali valde gibbosa.

α. Corolla flava vel flavescens, parvula, brevis, supra calycem incurva; carina inflexa. Pedunculi folia haud superantes.

63. A. DOUGLASII. *Phaca Douglasii*, Torr. & Gray, Fl. 1, p. 346; Hook. & Arn. Bot. Beech. p. 334. Adsurgens, subglaber vel puberulo-subcinereus; stipulis triangularibus discretis; foliolis 10-14-jugis

lineari-oblongis lanceolatisve apice obtuso vel apiculato; racemis brevibus laxifloris; dentibus calycis lato-subulatis tubo brevioribus; legumine gibboso-ovoideo, sutura ventrali fere recta. — California, near the coast, Douglas, Fremont, Brewer.

64. A. MACRODON. *Phaca macrodon*, Hook. & Arn. l. c. Adscendens vel erectus, villosulo-canescens, nunc glabriusculus; stipulis lanceolato-subulatis discretis; foliolis 11–14-jugis lineari-oblongis apice obtuso mucronato; racemis breviusculis; floribus demum deflexis; dentibus calycis sericei filiformi-subulatis laxi tubo æquilongis corolla (flavida) paullo brevioribus. — California, Douglas; in flower only. — A specimen with forming fruit, like that of the foregoing, collected by Dr. Gibbons, is ambiguous between the two, being glabrate, but with the calyx-teeth nearly of the present species, and with subulate rigid stipules.

b. Corolla alba vel ochroleuco-purpurascens, e calyce longius exserta, recta apice subincurva, alarum et carinarum unguibus lamina subæquilongis. Pedunculi folia superantes: racemi elongandi, multi-et conferti-flori, floribus mox deflexis. Foliola multijuga, conferta, apice sæpius retusa, infima cauli approximata.

65. A. CROTALARIÆ. *Phaca Crotalariae*, Benth. Pl. Hartw. p. 307? *P. densifolia*, Torr. Bot. Whipl. Exped. (Pacif. R. R. Surv. 4, p. 24, 80), non Smith. Glabratus vel subglaber; caule valido adscendente; stipulis triangularibus discretis; foliolis aut lineari- aut obovato-oblongis petiolulatis (6–16 lin. longis); corolla alba; legumine ovoideo 1–1½-pollicari chartaceo (rigidiori et minus inflato quam subsequentis). — California. Near Monterey, Coulter, if the plant here described be really Mr. Benthams species, as I am disposed to conclude, from a study of sketches and notes kindly furnished by him. But the specimens here described are by no means canescently pubescent, nor should I quite term their legumes “sub-coriaceous,” although the mature ones are considerably firmer in texture than those of the related species, — chartaceous they may be called: moreover, the teeth of the calyx are much shorter than the tube in Coulter’s plant, little shorter than the tube in our specimens; yet the following species shows a similar diversity in this respect. The flowers of Coulter’s plant, moreover, seem to be fewer, and the leaflets more cuneate-obovate; in all ours they are oblong. (It is certain that Coulter’s plant is not that figured by Dr. Torrey, our no. 57.) The materials before me are from the three following sources. Near San Francisco?

Dr. Gibbons, received from the late Dr. Darlington, with both flowers and ripe fruit. Cocomungo, Dr. Bigelow, from Dr. Torrey, with flowers and fruit. Valley of San Inez River, near Santa Barbara, Dr. Brewer, in the State Geological Survey; in flower and with forming fruit. In all these the leaves and stems are glabrous, except some scattered appressed hairs, especially on younger parts; the calyx sometimes considerably pubescent. Flowers 6 to 8 lines long.

66. A. MENZIESII. *Phaca densifolia*, Smith; Hook. Ic. t. 283, excl. syn. Nutt. *P. inflata*, Nutt. mss., non Gill. *P. Nuttallii*, Torr. & Gray, Fl. l. c. Villosa-canescens; caule decumbente glabrescente; stipulis scariosis adversus folium connatis; foliolis subcuneato-oblongis subsessilibus; legumine ovoideo "fere biunciali" tenui-membranacea. — California, near Monterey, Santa Barbara, &c. — There is an *As-tragalus densifolius* of Lamareck.

++ ++ Legumen brevi-stipitatum (stipite calycem adæquante); cæterum præcedentium. Stipulæ scariosæ folium adversus fere ad apicem usque (summis exceptis) connatæ.

67. A. CURTIPES (Gray in Proceed. Acad. Calif. ined.), sp. nov. Pube appressa minuta canescens, demum glabratus; caule erecto pedali; stipulis coalitis majusculis; foliolis 12–16-jugis oblongis seu lineari-oblongis retusis petiolulatis supra glabris; racemo fructifero brevi; calycis dentibus tenui-subulatis tubo campanulato parum brevioribus; legumine sesquipollicari puberulo glabrato semi-ovoideo (sutura ventrali fere recta, dorsali maxime gibbosa) utrinque vix acutato cum stipite rigido calycis tubum adæquante articulado. — San Luis Obispo, California, on the side of a dry hill, April 13th. Dr. Brewer. Corolla not seen.

++ ++ ++ Legumen longiuscule vel longissime stipitatum, $\frac{2}{3}$ –1½-pollicare, sutura ventrali convexiuscula recta vel concaviuscula. Stipulæ discretæ. Flores albi seu flaviduli, rectiusculi.

a. Stipes leguminis (basi haud vel parum attenuati) calycem longe superans. Pedunculi folium longe excedentes, racemo brevi oblongo terminati. Stipulæ parvæ.

68. A. LEUCOPSIS, Torr. & Gray, Bot. Mex. Bound. p. 56, t. 16. *Phaca canescens*, Nutt. in Torr. & Gray, Fl. 1, p. 344. *P. leucopsis*, Torr. & Gray, l. c. p. 694. Tomentuloso-canescens demumve cinereus; foliolis 10–18-jugis oblongis vel sublinearibus obtusis retusisve; dentibus calycis subulatis tubo brevi-campanulato dimidio brevioribus;

corolla ochroleuca; legumine glabro (subpollicari vel sesquipollicari) basi in stipitem calyce bis longiorem subattenuato. — Coast of California from Santa Barbara southward. — Calyx more or less pubescent, not silky. Ovary canescent. Legume often appearing as if acute or acutish at the apex, more so at the base. Stipe slender, five or six lines long.

69. A. LEUCOPHYLLUS, Torr. & Gray, Fl. 1, p. 236. *Phaca leucophylla*, Hook. & Arn. Bot. Beech. p. 333. Sericeo-incanus; foliolis 10–18-jugis lato-linearibus lanceolatisve obtusis vel acutiusculis; dentibus calycis sericei attenuato-subulatis tubo oblongo dimidio brevioribus; corolla ut videtur flavescente; legumine demum glabro (sesquipollicari) ovali-gibboso utrinque obtusissimo, stipite gracillimo ultra calycem prælonge (pollicem) exserto. — California, probably in the northern part of the State. The fruit is now known from the collection of Wilkes's Exploring Expedition (Sacramento Valley) and of a correspondent of the Rev. John Blake. Ovary silky-canescant, this pubescence remaining on the filiform stipe, which is fully as long as the half-grown legume.

70. A. TRICHOPODUS. *Phaca trichopoda*, Nutt. in Torr. & Gray, l. c. Cinereo-puberulus, glabratus; caule sesqui-tripedali; foliolis 12–19-jugis lineari-oblongis obtusis; calycis nigricanti-pubescent dentibus subulatis tubo campanulato multo brevioribus; corolla ochroleuca; ovario glaberrimo; legumine ellipsoideo utrinque obtusissimo haud pollicari stipite tenuissimo e calyce prælonge (semipollicem) exserto paullo longiore. — California, Santa Barbara and Monterey, Nuttall, Dr. Gambell, Dr. Brewer. Flowers $4\frac{1}{2}$ to nearly 6 lines long. Legumes only two thirds or three fourths of an inch long, much less gibbous than in the related species, a line from base to apex being nearly axial; the ventral suture only slightly convex to near the apex, where it is strongly convex. Stipe minutely pubescent.

b. Stipes calycem brevius superans. Legumen utrinque acutatum.

71. A. OXYPHYSUS (Gray in Proceed. Acad. Calif. ined.), sp. nov. Elatus, mollissime canescenti-villosus; stipulis scariosis; foliolis 8–11-jugis oblongis, junioribus incanis, adultis viridescentibus; pedunculis folium longe superantibus; racemo elongato; bracteis subulatis parvis; calycis sericei dentibus subulatis tubo cylindræco dimidio brevioribus; corolla "alba seu viridulo-alba" (lin. 9 longa); legumine obovato-clavato glabrato apice acute acuminato basi longe attenuato, stipite recurvo calycem parum superante. — California, Arroyo del Puerto, in

the Mt. Diablo range, on dry hills, June 11, in flower and fruit. Dr. Brewer. — A most distinct and striking species, apparently at least three feet high; the younger parts white, the older grayish with soft, villous pubescence. Larger leaflets an inch long. Flowers narrow. Legumes an inch and a half to two inches long, in the dried specimens all much flattened laterally and margined by the two nerviform sutures (the ventral one more or less convex), the general outline being nearly semi-obovate with an attenuated base and a sharp-pointed apex: but the pods are evidently inflated in the fresh plant, and therefore more clavate. The texture of the walls is that of a thin parchment-like membrane. Seeds numerous. Stipe 3 or 4 lines long, pubescent.

72. *A. FRIGIDUS*. *Phaca frigida*, L. Pedalis bipedalisve, subglaber; stipulis ovato-oblongis membranaceis; foliolis 7–9-jugis ovato-oblongis seu elliptico-oblongis viridibus; pedunculis folium adæquantibus; dentibus calycis abbreviatis; corolla alba; legumine oblongo utrinque acutato in stipitem calyce æquilongi vel longiori attenuato nigro-piloso vel in stirp. Amer. glaberrimo. — Rocky Mountains to the Arctic regions and the northern parts of the Old World.

§ 20. *Lonchocarp*i. Legumen membranaceum, lanceato-cylindricum, rectum, exserte stipitatum, glabrum, sutura neutra intrusa. Flores majusculi, calyce cylindraceo. Foliola pauca vel subnulla.

73. *A. LONCHOCARPUS*, Torr. & Gray, Bot. Whipl. Exped. in Pacif. R. R. Surv. 4, p. 24 (80). *Phaca macrocarpa*, Gray, Pl. Fendl. p. 36. Cinereo-puberulus, glabratus; caule fistuloso bipedali ramoso e radice perenni; stipulis discretis parvis; foliis 1–5-foliolatis quandoque ad rhachin complanato-filiformem reductis; foliolis filiformi-linearibus remotis; racemis plurifloris laxis; bracteis pedicello dimidio brevioribus; floribus pendulis albis; dentibus calycis lato-subulatis tubo quadruplo brevioribus; legumine (sesquipollicari) elongato-cylindrico, utrinque acutissime acuminato, stipite calycem excedente. — New Mexico, near Santa Fé.

The plant from the Llano Estacado, with shorter and blunt pods, collected by Dr. Bigelow, and noticed in the Pacific R. R. Survey, above cited, is not included in the character here given. When better known, it may prove to be a second species of this group.

§ 21. *Microcystei*. Legumen membranaceum vel chartaceum, parvum, globosum seu ovatum, vesicario-inflatum, estipitatum, sutura neutra introflexa. — E radice perenni diffusi vel procumbentes, plerique tenelli. Flores parvi, sæpius pauci.

74. *A. MICROCYSTIS*, sp. nov. Cinereo-pubescent, e radice lignescente procumbens; caulibus gracilibus ramosissimis; stipulis scariosis connatis summisve fere liberis; foliolis 4–6-jugis oblongis seu oblongo-lanceolatis obtusis; racemis 5–12-floris gracilibus; calycis pilosiusculis dentibus setaceo-subulatis tubo brevi-campanulato æquilongis; corolla violacea seu albo-violaceo, vexillo profunde emarginato alas paulo carinam incurvam bis superante; legumine inflato globoso-ovato tenuimembranaceo griseo-pubescente lin. 3 longo. — Interior of Washington Territory, Fort Colville to the Rocky Mountains, Dr. Lyall (ex herb. Kew. no. 4, 5, 6). — This has the aspect of *A. sparsiflorus*; and the flowers are similar; but the fruit is quite different, neither suture being at all introflexed, and resembling the *Inflati* on a very small scale.

75. *A. LEPTALEUS*. *A. (Phaca) pauciflorus*, Gray, Enum. coll. Parry, Hall, & Harbour, l. c. no. 141, non Hook. *Phaca pauciflora*, Nutt. in Torr. & Gray, Fl. 1, p. 348, fide herb. Durand. Fere glaber; caulibus tenellis adscendentibus (spithamæis); stipulis basi subconnatis elongato-subulatis; foliolis 7–11-jugis lanceolato-linearibus oblongisve sæpe acutis; pedunculis folio brevioribus 2–4-floris; calycis nigropilosiusculis dentibus subulatis tubo campanulato parum brevioribus; corolla alba, vexillo emarginato carina apice violacea tertia parte longiore; legumine ovato seu ovali puberulo chartaceo (lin. 4 longo) sub-obcompressum? — Valleys of the Rocky Mountains, in South Park, &c. — Flowers about 4 lines long, on pedicels about the length of the calyx-tube and of the subulate bract. Herbage tender: said to be a good forage plant where abundant; but it is small and slender. Nuttall states that he has seen but a single specimen, and that not in flower. There is only one specimen named by him in the Philadelphia collections, viz. in Mr. Durand's herbarium, and that is in flower only.

76. *A. THURBERI*, Gray, Pl. Thurb. p. 312, & Bot. Mex. Bound. p. 56. Pube minuta cinereus; caulibus suberectis (6–10-pollicaribus); stipulis discretis scariosis parvis; foliolis 6–7-jugis lineari-oblongis retusis crassiusculis; racemis spicisve laxe 10–20-floris in pedunculo brevi; dentibus calycis subulatis tubo parum brevioribus; corolla albidula; legumine coriaceo-membranaceo globoso glabello (lin. 3 diametro). — Arizona, on dry plains. — Flowers barely 3 lines long, on very short pedicels.

§ 22. *Bisulcati*. Legumen coriaceum, e calyce per stipitem brevem exsertum, leviter obcompressum, antice concavum, recessu sutura cariniformi maxime prominente percurso. — Glabelli vel glabri;

radice perenni ; stipulis discretis liberis. Flores mediocres leguminaque penduli seu patentes. Calycis dentes tubo campanulato vix breviores, setacei. Carina subrecta.

77. *A. BECKWITHII*, Torr. & Gray, in Pacif. R. R. Surv. 2 (coll. Beckwith), p. 120, t. 3. Glaber, humilis, diffusus ; foliolis late ovalibus ; floribus in racemo brevissimo 5–8 albis ; legumine ovali (pollicari) subincurvo acumine lato compressissimo apiculato, dorso planiusculo sutura levissime sulcata et intus tumida, ventre impresso sutura exserta acutissime marginata. — Utah. The legume described from a fruiting specimen communicated to the late Dr. Darlington by Capt. J. W. Phelps. — From the dorsal suture forming a slight internal ridge on that side of the cell, while the ventral is altogether externally salient, this would technically fall into the *Astragalus* rather than the *Phaca* series. But the conformation of the legume is more like that of *A. bisulcatus* than any other.

78. *A. BISULCATUS*, Gray, in Pacif. R. R. Surv. 12, pars 2, (Bot.) p. 38, t. 1, B. *Phaca bisulcata*, Hook. Fl. Bor.-Am. 1, p. 145. Striguloso-puberulus ; caule erecto ultrapedali valido ; foliolis oblongis sæpe angustis, imis stipulis approximatis ; racemis spiciformibus densifloris ; floribus violaceis ; legumine parvulo (semipollicari) recto anguste oblongo semicylindrico antice profunde bi-excavato. — Plains of Nebraska to the Saskatchewan and to the Rocky Mountains. — The ventral suture forms a strong and salient obtuse ridge of the same height as the borders of the deep excavation it divides.

§ 23. *Pectinati*. Legumen crasso-cartilagineum epicarpio subcarnoso, subovatum vel oblongum, turgidum, estipitatum, nec antice nec postice sulcatum vel intrusum, suturis crassis utrisque extus prominentibus. — Caules subpedales e radice perenni, foliaque rigidiusculi ; foliolis fere filiformibus rhachi haud articulatis persistentibus. Stipulæ inferiores adversus folium connatæ. Flores elongati (subpollicares) in racemo breviusculo plurimi, albi, carina rectiuscula.

(From the legume *A. microlobus* may be sought here.)

79. *A. PECTINATUS*, Dougl. *Phaca pectinata*, Hook. Fl. Bor.-Am. 1, p. 141, t. 54. Puberulo-cinereus, glabratus ; ramis striatis angulatis ; calycis dentibus tubo cylindræo multo brevioribus ; vexillo elongato ; legumine pendulo glabro (semipollicari) cuspidato, sutura dorsali percrassa. — Dry plains, Nebraska to Saskatchewan.

- § 24. *Scytocarp*. Legumen coriaceum, ovatum seu oblongum, rarius cylindricum, turgidum, nec antice nec postice sulcatum, sutura neutra introflexa. (Inter se valde diversi.)

(Here probably *A. microlobus*, no. 32, might also be sought.)

- * Legumen stipite crasso calycem subæquante sustentum. Flores magni (pollicares), calyce cylindræo.

80. *A. PREUSSII*, sp. nov. Fere glaber, e radice perenni? ultrapetalis; caule erecto; stipulis ovatis discretis; foliolis 6–8-jugis carnosulis subrotundis quandoque retusis (semipollicaribus); racemis spiciformibus brevibus plurifloris; bracteis ovatis parvis; dentibus calycis subulatis tubo 3–4-plo brevioribus; corolla ut videtur purpurea, carina subrecta alis paullo brevior, vexillo elongato; legumine ovali-oblongo recto duriusculè coriaceo inflato (pollicari) glaberrimo apiculato basi subito in stipitem validum contracto. — Banks of the Rio Virgen, a tributary of the Colorado in Nevada, near the eastern borders of California, in loose saline soil. Fremont, in second expedition, 1844. — A well-marked species, named in memory of Fremont's able assistant in all his earlier explorations, Mr. Charles Preuss. The only specimen is preserved in Dr. Torrey's herbarium. A pretty stout, large-flowered species, with firm, leathery, Baptisia-like pods, which are strictly one-celled, without introflexion.

* * Legumen haud vixve stipitatum.

+ Fere acaulescens, argenteo-sericeus, grandiflorus, radice perenni.

81. *A. CHAMELEUCE*, Gray in Bot. Ives' Colorado Exped. p. 10. *Phaca pygmæa*, Nutt. in Torr. & Gray, Fl. 1, p. 349. Cæspitoso-depressus (1–2-pollicaris); foliolis 2–5-jugis obovatis ovalibusque cano-sericeis; scapis brevibus 3–8-floris; calycis dentibus subulatis tubo cylindrico multoties brevioribus; corolla albo-violacea ($\frac{3}{4}$ -pollicari); legumine ovato-oblongo crasso-coriaceo (epicarpio subcarnoso?) tereti subarcuato puberulo (pollicari). — Upper waters of the Colorado of the West.

+ + Humiles e radice annua seu bienni, canescentes, parviflori; stipulis discretis.

82. *A. TEPHRODES*, Gray, Pl. Wright. 2, p. 45. Incano-villosus; caulibus perbrevibus; stipulis scariosis triangulari-ovatis; foliolis 7–12-jugis oblongis ovalibusque; pedunculis scapiformibus folia demum superantibus spicato-plurifloris; calycis dentibus tubo campanulato di-

midio brevioribus; corolla purpurea; legumine pubescente arcuato-ovato dorso gibboso acuto chartaceo-coriaceo (semipollicari et ultra).— New Mexico, Wright, Thurber, Bigelow.— Stems only an inch or two in length; the peduncles at length three inches long. Flowers rather small.

83. *A. ARIDUS*, sp. nov. Sericeo-canescens; caulibus spithamæis e radice annua diffuso-erectis foliosis; stipulis minutis; foliolis 5–6-jugis oblongis utrinque albo-sericeis; pedunculis spicato-5–8-floris folio brevioribus; calycis dentibus tubo brevi-campanulato brevioribus; corolla ochroleuca, minima (2–2½ lin. longa); legumine canescente gibboso-ovato (semipollicari) tenui-coriaceo inflato.— Interior Californian desert, on the route between the mouth of the Gila River and San Diego, Prof. Thurber. The materials are scanty. Perhaps the species has a truly membranaceous legume, and should rather be associated with *A. Thurberi*.

+ + + Piloso-sericeus, e radice perenni decumbens; floribus medio-ocribus; stipulis scariosis adversus folium connatis.

84. *A. SONORÆ*, Gray, Pl. Wright. 2, p. 44. Caulibus gracilibus decumbenti-diffusis prostratisve; foliolis 7–8-jugis oblongo-linearibus lanceolatisve acutatis pilis valde adpressis utrinque canescenti-sericeis; pedunculis folio longioribus spicato-8–12-floris; calycis dentibus setaceis tubo campanulato æquilongis; corolla incurva purpurea, carina inflexa apice rostratim producta; legumine canescenti-puberulo ovato-lunato acuminato turgido (semipollicari) chartaceo-coriaceo, suturis extus prominentibus.— On the borders of Arizona and the Mexican province of Sonora.— Flowers 4 or 5 lines long.

+ + + + Glabelli seu pubescentes; caules e radice perenni adsurgentes vel erecti, sæpius flexuosi; stipulis plerumque discretis; floribus parvis, in unica majusculis; leguminibus sæpe patentibus vel pendulis, stipite brevissimo in calyce occulto. Dentes calycis cinereo- vel nigricanti-pubescentis tubo breviores.

++ Legumina ovali-oblonga, inflata, subpollicaria, chartaceo-coriaceo.

85. *A. GRACILENTUS*. *Phaca gracilentæ*, Gray, Pl. Fendl. p. 36. Pube appressa subcanescens, erectus, subpedalis; foliolis oblongo-linearibus basi attenuatis; racemis laxifloris; corolla purpurascens (lin. 4 longa); legumine oblongo utrinque obtuso rectiusculo cinereo-pubescente in calyce arcte sessili.— Santa Fé, New Mexico, on rocky hills.

86. A. FENDLERI, Gray, Pl. Wright. l. c. *Phaca Fendleri*, Gray, Pl. Fendl. l. c. Glabellus vel pube appressa puberulus, erectus, ultrapetalis; foliolis oblongis seu lineari-oblongis; racemis longe pedunculatis laxifloris; corolla purpurea (lin. 4 longa); legumine ovali inflato recto apiculato minute puberulo, stipite brevissimo. — New Mexico, in the Mountains, &c.

87. A. HALLII, sp. nov. (*A. Phacæ debili* aff., Gray, Enum. coll. Parry, Hall, & Harbour, l. c. no. 121.) Subcinereo-pubescent, glabratus; caulibus pedalibus adsurgentibus; stipulis subulatis; foliolis 9–12-jugis angusto-oblongis subcuneatis retusis; pedunculis folium superantibus racemo densifloro capituliformi terminatis; floribus majusculis (lin. 7–8 longis); calycis nigricanti-pubescent dentibus latiusculis tubo campanulato basi gibboso 3–4-plo brevioribus; corolla violacea; legumine oblongo inflato glaberrimo recto apiculato stipite calyce triplo breviori suffulto. — Valleys of the Rocky Mountains of Colorado Territory, lat. 39°–41°, coll. Hall & Harbour, no. 121. — Stems rather stout. Leaflets 4–7 lines long. Flowers 20 or more in an open head or short and dense raceme, the rhachis in fruit at most an inch and a half long. Calyx broadly campanulate, very gibbous at the base, 3 lines long, the short teeth rather obtuse. Corolla straightish. Ovary very glabrous. Legume 7–10 lines long, very turgid, its short but distinct stipe about a line long. — This very well-marked species occurs in no other collection that I am aware of. Comparison with an original specimen of the little-known *Phaca debilis* of Nuttall does not confirm my former suspicion that this might be a larger form of that species. It may therefore appropriately bear the name of the assiduous discoverer.

++ ++ Legumina lineari-oblonga, cylindrica, tenui-coriacea.

88. A. FLEXUOSUS, Dougl. in Hook. Fl. Bor.-Am. 1, p. 141. *Phaca elongata* & *P. flexuosa*, Hook. l. c. Cinereo-puberulus, adsurgens, pedalis; foliolis oblongo-vel cuneato-linearibus obtusis retusisve; pedunculis folium superantibus; racemis plerisque elongatis laxis; calycis canescenti-pubescent dentibus tubo triplo brevioribus; corolla albida vel purpurascens (lin. 4 longa); legumine cylindraco (8–11 lin. longo lin. 2 diametro) puberulo apiculato recto vel subincurvo, stipite calyce occulto brevissimo sed manifesto. — Plains of Nebraska Territory to the Saskatchewan and the borders of the Rocky Mountains.

§ 25. *Podo-sclerocarpi*. Legumen crasso-cartilagineum, exserte stipitatum, compressum, incurvum, suturis valide incrassatis nequaquam intrusis a valvis demum secedentibus marginatum. — Perennes, ramosi, cinereo-puberuli, arenicolæ, stipulis parvis discretis.

89. A. SCLEROCARPUS. *Phaca podocarpa*, Hook. Fl. Bor.-Am. 1, p. 142. Ramosissimus, fere canescens; foliolis 6–9-jugis linearibus; racemis laxis; floribus albis; legumine canescenti-puberulo lunato nunc fere hamato acumine cuspidato basi in stipitem validum calyce bis terve longiorem attenuato, valvis rigidissimis turgidis rugulosis. — Dry, sandy barrens at the Great Falls of Columbia River, Douglas, and lately collected by Dr. Lyall, with ripe fruit. This when well formed is an inch long, and with the stipe not much shorter; the very thick valves become strongly convex. There is an *A. podocarpus* of long standing.

90. A. SPEIROCARPUS, sp. nov. Subcinereus, semipedalis; foliolis 4–9-jugis oblongis retusis; racemis paucifloris; legumine glabrato lineari-lanceolato complanato spiraliter 1–2-cyclo, stipite calycem bis superante. — Wenass, in the valley of the Upper Columbia River, Dr. Lyall, ex herb. Kew. In fruit only: the legume coiled like that of a *Medicago*. — The sutures, at least the thick ventral one, may be seen to separate more or less from the mature fruit in *A. gracilis*, *microlobus*, and I believe in *A. pectinatus*. In this and the preceding, both sutures become at length more or less detached, as in certain *Mimoseæ*.

§ 26. *Homalobi*. Legumen Viciæ- seu Ervi-forme complanatum vel pl. m. compressum, rectum, suturis nerviformibus nequaquam intrusis marginatum, coriaceum vel chartaceum, quandoque stipitatum. — Perennes, alii pinnatifolii foliolis pluribus paucisve, alii simplicifolii, habitu diversi. (*Homalobus* et *Kentrophyta*, Nutt.)

* *Genuini*; floribus in racemis spicisve pedunculatis; leguminibus pluri-(7–20-)ovulatis.

+ Stipulæ ut videtur omnes discretæ. Legumen exserte longèque stipitatum. Calycis dentes tubo 3–4-plo breviores. Caulescentes, plerumque ultrapedales, pinnatifolii, plurifoliolati.

91. A. COLLINUS, Dougl. in Hook. Fl. Bor.-Am. 1, p. 141. *Phaca collina*, Hook. l. c. Subcinereo-pubescens pube laxa, erectus vel diffusus; foliis linearibus seu oblongo-linearibus obtusis basi attenuatis; pedunculis folio duplo longioribus; racemo brevi oblongo confertifloro; floribus in pedicello suberecto retrofractis; calyce oblongo-

campanulato vel cylindraceo basi gibboso albido-pubescente, dentibus triangulari-subulatis; corolla fere alba calyce vix duplo longiori, vexillo carinam alasque subsuperante; legumine pubescente lineari-oblongo turgido basi in stipitem calyce bis longiorem attenuato. — Subalpine range of the Blue Mountains, Oregon, Douglas. On the Kooskooskie River, Dr. Pickering in Wilkes, Expl. Expedition (with fruit). Columbia Valley, Dr. Lyall, in flower. Described from the last two collections. Corolla purple according to Don, white with a purple spot on each petal according to Hooker, who had Douglas's notes. Legume an inch long including the stipe.

92. *A. FILIPES*, Torr. in Bot. S. Pacif. Expl. Exped. ined. Appresse-puberulus; caule gracili paniculato-ramoso; foliolis subremotis angustissime linearibus parvis (lin. 3–4 longis); pedunculis gracillimis folio multo longioribus; racemo sparsifloro; floribus in pedicello erectiusculo vel recurvo-patente nutantibus; calyce campanulato haud gibboso albido-puberulo, dentibus subulatis; corollæ albæ? vexillo carinam paullo superante; legumine fere glabro lineari-oblongo complanato basi in stipitem calyce ter longiorem angustato. — Interior of Washington Territory, near Fort Okanagan, Dr. Pickering in coll. Expl. Exped. — Flowers smaller than those of the preceding, and the legume apparently flat, an inch or rather less in length without the slender stipe, which commonly curves upwards out of the reflexed or spreading calyx.

93. *A. STENOPHYLLUS*, Torr. & Gray, Fl. 1, p. 329. *A. leptophyllus*, Nutt. in Jour. Acad. Philad. 7, p. 18, non Desf. Glaber, erectus; foliolis anguste linearibus (6–8 lin. longis); pedunculis folium bis superantibus; racemo oblongo 10–16-floro; floribus patentibus; calyce campanulato nigricanti-pubescente, dentibus latiusculis obtusissimis; corolla “purpurascens” seu alba, vexillo carina longiori; ovario glabro stipite vix æquilongo. — Rocky Mountains at the headwaters of the Missouri, Wyeth. Fruit unknown, but probably pertaining to this section. Ovary strictly one-celled.

+ — Stipulæ pleræque, saltem inferiores, adversus folium connatæ. Legumen pl. m. stipitatum. Caulescentes, pinnatifolii, semper plurifoliolati. Dentes calycis tubo dimidio breviores.

94. *A. MULTIFLORUS*. *Ervum multiflorum*, Pursh, Fl. 2, p. 789. *Astragalus tenellus*, Pursh, Fl. 2, p. 473, pro parte, ex Pursh. *Orobis dispar*, Nutt. Gen. 2, p. 95. *Phaca nigrescens*, Hook. Fl. Bor.-Am. *Homalobus dispar* & *H. nigrescens*, Nutt. in Torr. & Gray. *H. multiflorus*, Torr. & Gray, Fl. 1, p. 351. *Astragalus* (*Phaca*) *nigrescens*,

Gray in coll. Hall & Harbour, no. 115. Subglaber; caulibus adsurgentibus vel diffusis (sub- vel sesqui-pedalibus) ramosis; stipulis superioribus basi tantum connatis; foliolis 6-10-jugis angusto-oblongis linearibusque obtusis nunc mucronatis; racemis brevi-pedunculatis plurifloris laxis; floribus flavido-albis, carina rectiuscula alis brevioribus obtusissima apice nunc purpureo tincta; legumine oblongo plano glabro chartaceo (circiter semipollicari) stipite calycem subæquante rarius superante suffulto. — Plains of Nebraska to Mackenzie River (lat. 65°) and the Rocky Mountains. — The earliest specific name is fortunately not preoccupied in *Astragalus*, and may be adopted. It is only in Nicollet's specimens that I have seen the stipe much exceeding the calyx, — in these fully twice its length; but there is no clear distinction, either by the leaflets or the legumes, between Nuttall's two supposed species.

95? *A. BOURGOVII*, sp. nov. Striguloso-pubescent; caulibus e caudice lignescente adsurgentibus (spithamæis); stipulis fere omnibus alte connatis scariosis; foliolis 7-8-jugis oblongis lanceolatisve acutatis; pedunculis folia multo superantibus; racemo brevi 5-10-floro; pedicellis tubo calycis nigro-pubescent subæquilongis; corolla violacea, carina apice inflexa subproducta alas adæquante; legumine immaturo ovato-lanceolato nigro- vel cinereo-pubescente stipite brevi calyce incluso suffulto. — Rocky Mountains on the British Boundary, Bourgeau, in Palliser's expedition (ex herb. Kew.). — Mature fruit unknown, perhaps turgid and not of this section. The forming legume is rounded at the base, on a very short included stipe, the dorsal suture not at all introflexed. Flowers $4\frac{1}{2}$ or 5 lines long, apparently deeply colored: vexillum a little exceeding the wings and large keel. Calyx oblong-campanulate, acute at the base, the teeth rather stout. — I had taken this for the *A. vaginatus* of Richardson and Hooker. But I am informed that Richardson's specimen in the Hookerian herbarium is different, and has been referred by Planchon to *Phaca australis*.

96. *A. PALLISERI*, sp. nov. Parce striguloso-pubescent, glabratus; caulibus (subpedalibus) e caudice lignescente adsurgentibus ramosis gracilibus rigidulis; stipulis superioribus herbaceis discretis; foliolis 4-9-jugis linearibus lanceolatisve obtusiusculis; pedunculis folium æquantibus; racemo sparsi-(7-12)-floro; pedicellis calyce brevi æquilongis; corolla albido-purpurascens, carina apice angustata inflexa violacea alis brevioribus; legumine lineari ($\frac{2}{3}$ - $\frac{3}{4}$ -pollicari lineam lato) glaberrimo stipite brevissimo at manifesto calyce incluso suffulto,

valvis turgidis. — Rocky Mountains on the British Boundary, probably not at great elevations, Bourgeau, in Palliser's expedition (ex herb. Kew.). — Leaflets 7 to 12 lines long, a line or a line and a half wide, rather rigid. Calyx short-campanulate, the teeth not half the length of the tube, often still shorter. Corolla $4\frac{1}{2}$ to 5 lines long, curved; the carina produced into a narrow inflexed tip. Legume scarcely if at all exceeding a line in width, straight. It has a short stipe hidden in the calyx, like that of *A. flexuosus*, which is the species of *Scytocarp*i most approaching the *Homalobi* in the narrowness of its pod, and which the present species somewhat resembles. But the flowers of this are larger, and differ much in the narrow and inflexed tip to the keel. The pods with turgid valves resemble those of *A. collinus*. But its near affinity is with *A. campestris* and *A. decumbens*, from which the glabrous legumes, on a manifest though short stipe, distinguish it.

+ + + Stipulæ pleræque, saltem inferiores, adversus folium connatæ. Legumen nunquam stipitatum. Caulescentes.

++ Calycis dentes gracillimi tubo sublongiores. Humiles e caudice lignescente, omnino pinnatifolii; stipulis omnibus pl. m. connatis.

97. *A. PAUCIFLORUS*, Hook. Fl. 1, p. 149. Multicaulis, pumilus, cinereo-pubescent; caulibus cæspitanti-decumbentibus conferte foliosis stipulis majusculis; foliolis 3–5-jugis oblongis lanceolatisve acutis pedunculis folium subæquantibus 2–5-floris; floribus approximatis racemosis patentibus; corolla violacea, carina breviter incurva obtusissima alis satis vexillo dimidio brevior; legumine lineari-oblongo complanato sericeo-puberulo (lin. 4–5 lin. longo). — Elevated regions of the Rocky Mountains, near the British Boundary. The fruit, that of a genuine *Homalobus*, is described from Bourgeau's specimens. Corolla $4\frac{1}{2}$ to 5 lines long, curved, the large vexillum reflexed.

98. *A. MISER*, Dougl. in Hook. Fl. Bor.-Am. 1, p. 153, adn.? Multicaulis, cinereo-puberulus; caulibus diffusis (spithamæis) gracilibus laxè foliatis; stipulis majusculis, superioribus ad medium connatis; foliolis lato-linearibus oblongisve plerumque obtusis; pedunculis folium longe superantibus 5–12-floris; floribus in racemo sparsis; corolla et calyce fere præcedentis; legumine juvenili ovato-oblongo canescente. — Valley of Columbia River, Dr. Lyall (ex herb. Kew.), and, if the same, of its tributary the Spokane, Douglas. Described from Dr. Lyall's specimens (no. 7), and (the fruit being wanting) referred here on account of its resemblance to the preceding species. Douglas's

name may as well be taken up for this species from the same district. No specimens named by Douglas are extant.

++ ++ Calycis dentes aut breves aut tubo subæquantes. Stipulæ superiores fere discretæ. Graciles, rigiduli, ramosi, pinnatifolii vel abortu subsimplicifolii, nunc petiolis nudis. Racemi laxiflori, longius pedunculati. Flores ochroleuci, nunc purpureo suffusi; carina præsertim violaceo tincta vexillo parum brevior.

99. A. CAMPESTRIS. *Homalobus campestris* & (forma depauperata) *H. tenuifolius*, Nutt. in Torr. & Gray, Fl. 1, p. 351. *H. decumbens*, Gray in Enum. coll. Parry, Hall, & Harbour, no. 142, non Nutt. Striguloso-cinereus, nunc glabrescens; caulibus adsurgentibus (3–15-pollicaribus); petiolis subcomplanatis rigidis sæpius 9–13-foliolatis, summis raro paucifoliolatis nudisve; foliolis lanceolatis linearibus seu lineari-subulatis plerumque acutis; racemis 5–10-floris; calycis dentibus tubo dimidio brevioribus; carina apice inflexa longe rostratim producta; legumine oblongo-lineari (subpollicari) puberulo, valvis sub-turgidis. — Colorado Territory, in valleys on both sides of the Rocky Mountains. — Variable in size and in the leaflets, but well marked by the long and narrow falcately inflexed tip to the carina. Flowers rather large, fully 5 lines long when well developed, yellowish-white, usually tinged with violet.

100. A. SEROTINUS, Gray in Pacif. R. R. Surv. 12, 2, p. 47, t. 5. Cinereo-puberulus, glabratus; caulibus adsurgentibus (9–18-pollicaribus); petiolis omnibus pluri-(9–21)-foliolatis; foliolis linearibus; racemis virgatis 9–20-floris; calycis dentibus brevissimis (tubo 3–4-plo brevioribus); carina apice brevi subangustata inflexa; legumine lineari fere glabro. — On the Okanagan near the Columbia River, lat. 48°, Oct., Dr. J. G. Cooper. — Flowers tinged with purple, almost as large as in the preceding species, but the carina very different, having a much shorter and broad inflexed tip. From the next species the distinctions are not so certain, being chiefly the less pubescence and the short calyx-teeth.

101. A. DECUMBENS. *Homalobus decumbens*, Nutt. l. c. Cinereo-vel sericeo-pubescent; caulibus diffusis vel adscendentibus (6–10-pollicaribus); petiolis nunc subcomplanatis plerisque pluri-(7–13)-foliolatis; foliolis lineari-lanceolatis acutis; racemis 5–10-floris; calycis dentibus attenuatis tubo parum brevioribus; carina apice brevi inflexa; legumine lato-lineari recto vel falcato (subpollicari) canes-

centi-puberulo. — On both sides of the Rocky Mountains in Colorado Territory, and farther northward. — Corolla 4 or $4\frac{1}{2}$ lines long, ochroleucous, sometimes with a purplish tinge.

102. *A. DIVERSIFOLIUS*. *Homalobus orthocarpus*, Nutt. l. c. Striguloso-cinereus; caulibus diffuso-decumbentibus elongatis (pedalibus); petiolis brevibus complanatis 1–5-foliolatis; foliolo terminali seu folio simplici lineari elongato (1–2-pollicari) utrinque attenuato; pedunculis 1–5-floris; calycis dentibus tubo dimidio brevioribus; carina falcato-incurva; legumine oblongo-lineari recto vel subfalcato ($\frac{3}{4}$ -pollicari) canescenti-puberulo. — Gravelly plains of Colorado Territory, on both sides of the Rocky Mountains. — Flowers ochroleucous or lurid. — There is an *A. orthocarpus* of Boissier; and moreover the pods of this, as of the foregoing species, are often more or less falcate.

103. *A. JUNCEUS*. *Homalobus junceus*, Nutt. l. c. Striguloso-cinereus; caulibus erectis paniculato-ramosis; petiolis filiformibus aphyllis, “radicalibus foliola 1–2-juga minima gerentibus”; pedunculis paucifloris; calycis dentibus brevissimus obtusis; legumine lineari recto canescenti-puberulo. — Colorado Territory, on the head-waters of the Colorado of the West. — The only extant specimen of this in American herbaria, that I can find, is one in Dr. Torrey’s herbarium, given by Nuttall, out of flower, and bearing a single legume, which is nearly an inch long. If distinct (and I know not to what other of the group it could be united), it may retain Nuttall’s specific name, the *A. junceus* of Ledebour being a synonyme of *A. Stevenianus*.

+ + + + *Stipulæ scariosæ folium adversus in unum connatæ. Legumen breve, nunquam stipitatum, oligospermum. Acaulescentes, cæspitosi, sericeo-canescents; foliis simplicibus lanceolato-vel spathulato-linearibus, nonnullis raro 3–5-foliolatis; scapis folia superantibus plurifloris; corollis purpureis vel roseis.*

104. *A. CÆSPITOSUS*. *Homalobus cæspitosus, brachycarpus, & canescens*, Nutt. l. c. Late cæspitans; scapis 2–6-pollicaribus; racemo spiciformi; calycis dentibus attenuatis tubo subæquilongis; carina obtusissima vexillo multo brevior; legumine oblongo seu lato-lanceolato vix curvato (lin. 3–5 longo) subplano. — Dry hills and cliffs of the Platte or Nebraska, towards the Rocky Mountains. — Ovary and legume more or less canescent in Nuttall’s specimens of his three species, which are all evidently reducible to one; while the ovary is glabrous in a specimen collected at Scott’s Bluffs by Mr. W. H. Wagner.

* * *Condensati*; floribus e rosulis foliorum simplicium vix exsertis; leguminibus pluriovulatis subturgidis suturis validioribus marginatis.

105. A. SIMPLICIFOLIUS. *Phaca simplicifolia*, Nutt. l. c. Pulvinato-cæspitosus; foliis lineari- vel spathulato-lanceolatis rigide acutis sæpius involutis sericeo-incanis ramos breves caudicis multicipitis dense obtegentibus; scapis brevissimis inclusis demum subexsertis; calycis glabrati dentibus tubo oblongo dimidio brevioribus; corolla parvula ochroleuca; legumine calyce semi-incluso oblongo acuto subcompresso glabro crasso-coriaceo, sutura ventrali recta acutissima, dorsali gibbosa. — Rocky Mountains of Colorado Territory near the sources of the Platte, found only by Nuttall. — Legume four lines long, of thicker texture and more turgid than in the preceding species, and with more prominent sutural edges, but formed on the same plan; the foliage also similar. Ovules about 12.

* * * *Submonospermi*, depresso-caulescentes; floribus in axillis foliorum subsessilibus; leguminibus 3–4-ovulatis sæpius monospermis ovatis haud stipitatis. Pinnatifolii, paucifoliolati.

106. A. KENTROPHYTA, Gray, Enum. coll. Parry, Hall, & Harbour, l. c. no. 106. *Kentrophyta montana* & *K. viridis*, Nutt. in Torr. & Gray, l. c. Intricato-ramosus e radice longa, late depresso-cæspitosus, undique foliosissimus, sericeo-canescens; stipulis folium adversus plerisque connatis; foliis pinnato-3–7-foliolatis; foliolis lineari-subulatis divaricatis rigidis mox involutis spinula terminatis cum rhachi haud articulatis persistentibus; floribus in axillis 1–3 parvis cæruleo-albidis ochroleucisve; legumine ovato acuminato compresso tenui-coriaceo canescente parvo (lin. 3 longo) bivalvi basi calyce brevi stipato suturis vix marginato. — Colorado Territory, on both sides of the Rocky Mountains, especially on the upper part of the Platte or Nebraska, in denuded or sandy places.

2. Folia quasi palmato-trifoliolata. (*Phaca* § *Orophaca*, Torr. & Gray.)

§ 27. *Triphylli*. Legumen conico-ovatum, acuminatum, nec stipitatum nec compressum, coriaceum, pluriovulatum, calyce subinclusum, sutura neutra intrusa. — Perennes, e caudice multicipiti lignescente cæspitosi, depressi, argenteo-sericei, confertifolii; stipulis majusculis tenui-scariosis adversus petiolum connatis ramos imbricantibus. Folia simulate palmatim re vera pinnatim trifoliolata, infima rarissime bijugatum 5-foliolata, foliolis confertis.

107. A. TRIPHYLLUS, Pursh, Fl. 2, p. 740. *Phaca cæspitosa*, Nutt. Gen.; Hook. Fl. Bor.-Am. t. 55. *P. argophylla*, Nutt. in Torr. & Gray, l. c. Acaulescens, nitido-sericeus; stipulis hyalinis glabris; foliis primariis quandoque 5-foliolatis foliolis cuneato-oblançeolatis, sequentibus longe petiolatis foliola 3 longiora lanceolata gerentibus flores (pollicares) sessiles confertos superantibus; calycis dentibus tubo cylindrico dimidio brevioribus; corolla ochroleuca seu alba; legumine villosa calyce incluso. — Plains of Nebraska to the Saskatchewan. — Even the trifoliate leaves may be seen on close examination to be of the pinnate type, and not of the palmate, as I had supposed. Some of the earlier leaves of the season (which, by their shorter petioles and shorter and broader leaflets, exemplify Nuttall's *Phaca argophylla*), moreover, show two pairs of leaflets and a terminal one, crowded indeed, but evidently pinnate. Pursh's name is to be restored to the species, the homonyme of Pallas being an *Oxytropis*.

108. A. SERICOLEUCUS, Gray, Enum. coll. Parry, in Sill. Jour. n. ser. 33, p. 410, no. 190. *Phaca sericea*, Nutt. in Torr. & Gray, Fl. l. c. Latissime cæspitosus, sericeo-incanus; caulibus ramosis prostratis; ramis stipulis villosis obtectis; foliis omnibus trifoliolatis pedunculos filiformes 2-6-floros haud æquantibus; foliolis oblançeolatis cuneato-oblongisve (lin. 3 longis); calycis dentibus tubo campanulato subæquilongis; corolla purpurea (lin. 3-4 longa); legumine ovato-oblongo incano calyce semi-incluso (lin. 3 longo). — Sand-hills and cliffs of the Platte or Nebraska to the Rocky Mountains.

III. Species anomala, carina in acumen producta *Oxytropidis* instar, legumine sutura dorsali (carinali) solum introflexa Astragalorum typicorum.

109. A. NOTHOXYS, sp. nov. Diffusus e radice annua, cinereo-puberulus; caulibus gracilibus (3-12-pollicaribus); stipulis fere liberis discretis; foliolis 6-9-jugis obovato-oblongis oblongisve sæpe retusis supra glabris; pedunculis folium superantibus; racemo brevi spiciformi; calycis dentibus subulatis tubo oblongo brevioribus; corolla violacea, carina apice lato incurvo in acumen acutissimum desinente; legumine lato-lineari falcato puberulo tenui-coriaceo dorso sulcato septifero fere bilocellato, sutura ventrali extus prominula. — Arizona, formerly the northern part of the Mexican province of Sonora, Prof. Thurber. San Luis Mountain and Guadalupe Cañon, Capt. E. K. Smith, in herb. Torr. — Leaflets 3 to 6 lines long. Peduncles 3 to 6

inches long. Flowers about half an inch long. Legume 8 to 11 lines long, transversely venulose, many-seeded, considerably resembling that of *A. Nuttallianus*, with which (notwithstanding the obvious differences) some of the specimens were confounded in the Botany of the Mexican Boundary Survey. The broad and short, moderately incurved apex of the carina is abruptly contracted into a short, very acute, porrected cusp, which would technically refer the plant to *Oxytropis*.

* * * *Obscure Species.*

A. DIAPHANUS, Dougl. in Hook. Fl. Bor.-Am. 1, p. 151, — from near the Great Falls of the Columbia River, — described as having linear, somewhat diaphanous, bilocellate legumes, I have not identified. I learn that the plant has the aspect of *A. distortus*.

A. COULTERI, Benth. Pl. Hartw. p. 307, near Monterey, California, with silky-villous bilocellate legumes, would seem to belong to the section *Argophylli*.

A. POLARIS, Benth. in Hook. f., Arct. Pl. (Linn. Trans. 33, p. 323), from Kotzebue's Sound, is said to differ from *A. alpinus* not only in the size (an inch long) and upright direction of the legume, and the obsolete stipe, but also in the absence of any introflexion of the dorsal suture.

PHACA DEBILIS, Nutt. in Torr. & Gray, Fl. 1, p. 345, from the Rocky Mountains, is known to me only by a flowering specimen in herb. Torr. In appearance, and in the size of the flowers, it seems intermediate between *A. Hallii* and *A. flexuosus*; but it is dwarf, and has shorter calyx-teeth than either. The legume is a desideratum.

PHACA PARVIFOLIA, Nutt. l. c. p. 348, I find no specimen of; but conjecture that it may, like Nuttall's *P. parviflora*, have been founded on *P. elegans*, Hook., which is the small-flowered, American variety of *A. oroboides*.

Among *Astragali* which remain undetermined for want of sufficient materials are the following: —

1. A striking one collected, in blossom only, by Capt. Pope, on the Llano Estacado, with a head or short spike of large yellowish flowers. It is mentioned in the Botany of Pope's Exploration; Pacif. R. R. Surv. 2, p. 163.

2. The plant, in flower only, described as a variety of *A. Fremontii*, in Pacif. R. R. Surv. 4, p. 80 (24), collected by Dr. Bigelow on the Mohave, but which is certainly different from Fremont's plant there

characterized. Dr. Parry gathered the same species on the Gila, still without fruit.

3. A canescent, narrow-leaved species from "Tubac, Sonora, Parry," which in the Bot. Mex. Bound. Surv., p. 56, was referred to *A. Sonoræ*. Capt. E. K. Smith collected the same species at Los Nogales, Sonora, also without fruit.

4. A plant mentioned in Torr. & Gray, Fl. 1, p. 694, under *Phaca leucophylla*, from Douglas's last collection, of which the legumes only are known; these are ovate-oblong, rather cartilagineous than coriaceous, entirely one-celled.

OXYTROPIS, DC.

The few North American species of *Oxytropis* of which materials are before me appear to be as follows:—

A. Calyx fructifer vesicarius.

§ 1. *Calycophysæ*. (*Physocalyx*, Nutt. ined.) Calyx fructifer vesicario-inflatus, globosus, legumen ovatum chartaceo-membranaceum sutura ventrali solum intrusa sub-semibilocellatum includens. Pulvinato-cæspitosæ, subacaules: scapi biflori.

1. *O. MULTICEPS*, Nutt. in Torr. & Gray, Fl. 1, p. 341; Gray in Enum. coll. Parry, Hall, & Harbour, no. 144 (forma minor). *Physocalyx multiceps*, Nutt. in herb. Rocky Mountains.—The legume of this most rare and charming little alpine species resembles that of *O. pumila*, Fischer, but is short-stipitate, and concealed in the persistent bladdery calyx.

B. Calyx immutatus.

§ 2. *Physocarpæ*. Legumen vesicario-inflatum, membranaceum, sutura ventrali solum intus tumida vel intrusa. Acaulescentes: scapi umbellato- seu capitato-2-6-flori.

2. *O. PODOCARPA*. *O. arctica*, Hook. Fl. Bor.-Am. 1, p. 146, pro parte, non R. Br. *Astragalus biflorus*, Schweinitz in herb. Depressocæspitosa, multiceps, albo-villosa, demum glabrescens; stipulis petiolo longe adnatis; foliolis 5-11-jugis crebris lineari-lanceolatis seu oblongo-linearibus (lin. 2-4 longis); pedunculis folia adæquantibus bifloris; corollæ (subcæruleæ?) carina brevi-mucronata; legumine (subpollicari) oblongo-ovato tenui-membranaceo subglabro acutissime acuminato stipite gracili calycem adæquante sustento.—Labrador, Arctic regions, and Rocky Mountains, lat. 49°. The specimens before me are from

Labrador, good flowering specimens in the herbarium of Schweinitz; from Arctic America, one in Dr. Torrey's herbarium, ticketed "*O. campestris* (Parry) by Sir William Hooker (which may perhaps be his *O. campestris* var. *melanocephala*, but the short peduncles are at most two-flowered), and one from Richardson named by him *O. arctica*; from the Rocky Mountains, Sir William Hooker's *O. arctica* ♂, of Drummond's collection;—all the above in blossom only; and, finally, a fruiting specimen of the latter from Bourgeau's collection. This, with its thin-walled inflated legume on a slender stipe (which stipe is evident enough in such flowers of the above as I could venture to dissect), is thus shown to differ essentially from the original *O. arctica*, which has the coriaceous nearly sessile legume, along with other characters of *O. Uralensis*. The present species is surely more nearly related to *O. physocarpa*, Ledeb., differing however in its stipitate and pointed pod, and in the merely conjugate, but much crowded leaflets.

§ 3. *Campestris*. Legumen coriaceum seu chartaceum, nec vel parum vesicarium, in calyce sessile vel substipitatum, sutura ventrali septifera fere vel semi-bilocellatum, sutura dorsali raro subintrusa. Acaules: stipulæ petiolo alte adnatæ: scapi raro 2–4-flori, sæpius pluriflori; floribus capitatisve; leguminibus erectis.

* Foliola conjugata.

+ Scapi 2–5-flori.

3. *O. URALENSIS*, L. var. *PUMILA*, Ledeb. Fl. Alt. *O. arctica*, R. Br.; Hook. pro parte. *O. Uralensis*, var. *arctica*, Ledeb. Fl. Ross. *O. lagopus*, Nutt. in Torr. & Gray, Fl. — Arctic shores and islands; and Rocky Mountains to about lat. 40°, Nuttall, Hall and Harbour, no. 143. — I can well believe that this is an arctic-alpine form of *O. Uralensis*. The legumes are oval-oblong or elongated-oblong, with the partition from the ventral suture stretching across to the dorsal. But neither in this nor in Siberian specimens of genuine *O. Uralensis* (I have no fruiting European) do I detect any wing or rudiment of a septum projecting from the dorsal suture, as described by authors.

+ + Spicæ vel capitula plurifloræ.

4. *O. CAMPESTRIS*, L., cum syn. Ledeb. & Hook. f. *O. viscida*, Nutt. in Torr. & Gray (*O. mollis*, Nutt. herb., forma viscidulo-villosa). Legumina chartacea, ovata seu ovato-oblonga, subinflata. Flores lutescentes, violaceo suffusi vel picti, rarius cærulei. Foliola plurijuga, oblongo-lanceolata, haud sericeo-canescientia. — Arctic regions to Lab-

rador, Maine, and Rocky Mountains, lat. 40°. In legumes of European *O. campestris*, but not in the plant of Maine, I find a slight internal projection of the dorsal suture; also, that the septum from the other suture divides the cell, except when the legume is considerably inflated. From the observations of Ruprecht, Ledebour, and others, it would seem that *O. campestris*, *argentata*, and *Uralensis* all run together. Equally they appear to run into the next in the Saskatchewan and Rocky Mountain region.

5. *O. LAMBERTI*, Pursh. *O. Hookeriana?* *Plattensis* & *sericea*, Nutt. in Torr. & Gray. Legumina coriacea, nunc fere cartilaginea, arrecta, oblongo-cylindracea seu elongato-cylindracea (lin. 2-3 lata, longiora pollicem longa), septo e sutura ventrali fere bilocellata. Flores majusculi seu magni (8-12 lin. longi), spicati, purpurei, violacei, ochroleuci, seu albi. Foliola plurijuga, lanceolata, oblonga, vel linearia, cum calycibus canescenti-sericea. Stipulae plerumque hirsutissimae seu lanatae. — Plains of Saskatchewan to Texas and the Rocky Mountains. I am unable to compare this with the Siberian *O. grandiflora*.

6. *O. NANA*, Nutt. in Torr. & Gray, l. c. *O. argentata*, Pursh. Fl.? non Pall. Cæspitoso-multiceps; folia confertissima, magis cano-sericea; foliola 3-4-juga. Flores 9-12, capitati, majusculi. — Rocky Mountains about lat. 40°, Nuttall; and farther north on Little Blackfoot River, Dr. Cooper; in flower only. Legumes unknown.

* * Foliola pleraque subverticillata.

7. *O. SPLENDENS*, Dougl. in Hook. A well-marked and beautiful, silvery silky-villous species. Plains of Nebraska to Bear Lake, and west into the Rocky Mountains.

§ 4. *Montanae*. Legumen tenuiter coriaceum, oblongum seu cylindraceo-elongatum, in calyce breviter vel brevissime stipitatum, sutura ventrali late impressa (haud vero septifera) sub-semibilocellatum. Caulescentes vel subacaules, pedunculis scapiformibus: stipulae praesertim superiores basi tantum petioli adnatæ: foliola crebra: flores læte cærulei, spicati seu capitati, parvuli (tubo calycis brevi), patentes; leguminibus sæpius patentibus seu deflexis.

8. *O. DEFLEXA*, DC. *O. foliolosa*, Hook., forma fere acaulis. — Saskatchewan to the Rocky Mountains, as far south as about lat. 40°. (Fine specimens in Parry, Hall, and Harbour's collection, no. 120.) The only species of this group yet detected in America.

Five hundred and twenty-eighth Meeting.

December 8, 1863. — ADJOURNED STATUTE MEETING.

The PRESIDENT in the chair.

The Treasurer reported that it was not advisable to make any change in the mode of accounting for the trust funds of the Academy. On the motion of Professor Lovering, this report was accepted.

Messrs. B. A. Gould, Lovering, A. Gray, Beck, and Winthrop were appointed a committee to consider and report upon the meaning of Chapter IX., Sections 2 and 3, of the Statutes of the Academy, in relation to nominations made at adjourned Stated Meetings.

Five hundred and twenty-ninth Meeting.

January 12, 1864. — MONTHLY MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read letters from George Bancroft and Frederic E. Church of New York, from Henry C. Cary of Philadelphia, John P. Kennedy of Philadelphia, and William Lawrence of London, in acknowledgment of their election as members of the Academy.

The President called the attention of the Academy to the recent decease of Dr. Francis Boott of London, of the Associate Fellows; and also of Mr. Francis Alger, a Resident Fellow.

Dr. Dean exhibited a series of photographs, obtained by the microscope, of sections of the *medulla oblongata* of man and other mammals.

Five hundred and thirtieth Meeting.

January 27, 1864. — STATUTE MEETING.

The PRESIDENT in the chair.

On motion of Dr. B. A. Gould, it was voted that a committee be appointed to consider the expediency of expunging the words "hereafter elected" in Chapter IX., Section 2, of the Statutes of the Academy, and to consider whether any other, and, if any, what changes in the Statutes are desirable. Messrs. J. A. Lowell, Parsons, Sparks, Winthrop, and B. A. Gould were appointed to serve on this committee.

The following gentlemen were elected members of the Academy:—

Mr. Ralph Waldo Emerson, to be a Resident Fellow in Class III., Section 4.

Mr. Richard H. Dana, Jr., to be a Resident Fellow in Class III., Section 1.

Professor J. P. Lesley of Philadelphia, to be an Associate Fellow in Class II., Section 1.

Professor Wyman presented a Memoir "*On the Development of Raia Batis.*"

Five hundred and thirty-first Meeting.

February 9, 1864. — ADJOURNED STATUTE MEETING.

The PRESIDENT in the chair.

Professor Lovering, from the Rumford Committee, presented the following Report.

"The Academy having voted (June 1, 1862), that six hundred dollars be paid to Philander Shaw, to be expended by him in experiments or investigations relative to air-engines, the Rumford Committee have considered themselves under obligation to watch the progress of these and similar experiments, &c., and occasionally to report upon them to the Academy.

"The Committee have examined all the air-engines in Boston that they have been able to find after diligent inquiry, and they believe that they have obtained as much and as accurate information in regard to them as could be had; and as much as seemed, in the present state of the question, useful.

"They find three kinds of engines in practical operation: 1st, Mr. Ericsson's, to which the Rumford medal was awarded by the Academy at the adjourned annual meeting in June, 1862; 2d, Mr. Shaw's; and 3d, Mr. Roper's. Engines by these inventors were at work in Boston or its vicinity at the time of that award, and were described in the discussions which were had on the Report of the Rumford Committee at that time. The Ericsson engines which were then at work in Boston are still at work; but the Committee have not been able to find that another of this kind has been added to the number; and they believe that no addition has been made.

"All measurements of these engines have shown that their *nominal* power greatly exceeds their actual useful effect. The Committee have found, in every one measured, the actual power to be only from one eighth to one seventh of that for which the engine was purchased.

"The first one submitted to the Rumford Committee of the preceding year (estimated at one horse-power) measured only one seventh of one horse-power. Two other four-horse engines each measured from two thirds to three fourths of one horse-power; and the two-horse engine at the office of the 'Medical Journal' measured only one fourth of one horse-power. These engines consume about fourteen pounds of coal to the horse-power per hour. These measures were taken as the machines were found at their ordinary work, and are believed to express with sufficient accuracy their performance under ordinary circumstances.

"The engines of Mr. Shaw and Mr. Roper, while they differ from each other in some important particulars, are similar in the points to which the former Rumford Committee attached most value. They both work under pressure, and heat the air by passing it directly through the flame, without the intervention of any conducting substance. They are also independent of the draught of a chimney, and are as effective in the attic as in the basement of a building; moreover, they are almost, if not quite, as steady and as noiseless as a steam-engine.

"Mr. Shaw, during the past year, has been engaged in experiment-

ing upon his engine, chiefly with a view to secure as great economy in fuel as possible. He has sold several engines, however, which seem to have given satisfaction, and has now several others nearly completed. He has increased the power of his engine considerably by adding a small tubular boiler, in which steam is generated by the heat of the exhaust air. This boiler communicates with his reservoir of condensed air, and increases and equalizes the pressure. The Committee have found his estimates of the power of his engines correct. Those from two to three horse-power consume about $2\frac{1}{2}$ pounds of coal to the horse-power per hour. None of his engines have been in operation long enough, however, to put their practical success beyond question, although one of them has now been in constant use for four months, giving satisfaction to its owner. The Committee believe that Mr. Shaw has, or will have, after a few changes, a successful engine.

“Mr. Roper’s experiments have been directed rather to improvements in other respects than to securing economy in fuel. His engine has been greatly improved since the last report of the Rumford Committee. Mr. Roper has finally settled on the form which he will retain, and has begun to manufacture engines from it on a large scale. The ease with which this engine can be repaired, and the facilities which its construction afford for its manufacture *in great numbers*, will probably lead to its very general use. It consumes not more than five pounds of coal to the horse-power per hour. The Committee believe this to be the most successful hot-air engine now at work in Boston. The largest size made, up to this time, is two-horse-power.”

Dr. B. A. Gould presented a report from the committee appointed to consider the intent of the statutes concerning the election of Fellows. The report was accepted, and a recommendation to modify the statute, Chapter IX., Section 2, by substituting the words “at least ten weeks,” for the words “the interval between two stated meetings,” was referred to the Committee on amending the Statutes.

Dr. B. A. Gould was excused from serving on the committee, and the President was appointed in his place.

The following gentlemen were elected members of the Academy, viz. : —

To be Foreign Honorary Members:—

Henry H. Milman, the Dean of St. Paul's, London, in Class III., Section 3, in place of Archbishop Whately, deceased.

Professor Max Müller of Oxford, in Class III., Section 2, in place of Jacob Grimm, deceased.

Frederick Overbeck of Rome, in Class III., Section 4, in place of the late Christian Rauch.

Professor Thomas Graham, Master of the Mint, London, in Class I., Section 3, in place of Professor Mitscherlich.

To be Associate Fellows:—

Major-General George G. Meade, U.S. A., in Class I., Section 4.

Professor Ogden N. Rood of New York, in Class I., Section 3.

To be Resident Fellows:—

Mr. Edward Pearce and Dr. William Watson of Cambridge, both in Class I., Section 1.

Dr. H. R. Storer called attention to a matter that might be considered as of general interest, the result of investigations he had for some years been making into *the causation of insanity among women*. From the facilities of observation afforded him by a large special practice, and more lately by his position as one of the State Commissioners on Insanity, he had been irresistibly led to certain conclusions that were apparently of scientific and practical value. They were not at variance with what had previously been enunciated upon the subject, but they promised to open a new and fruitful field for explanation and curative treatment. He proposed the following as general laws:—

“1. In women of insane tendency, accidental or by inheritance, the access of insanity, its increase and its results, are more likely to occur at times of uterine or ovarian excitement, whether periodical and normal, or from disease.

“2. In women, mental derangement, even of extreme character, is very commonly, indeed almost constantly, the consequence of uterine or ovarian derangement, however trifling; occurring at puberty, at the grand climacteric, or at any point between them, during virginity, during gestation, during or after labor, or during lactation, from excessive sexual gratification, or excessive sexual abstinence, from self-abuse, from organic or functional local lesion.

"3. So large a proportion of the mental derangements of women being sympathetic and reflex, and referable to local derangements, herein differing from what obtains in men, where insanity is more frequently of centric and cerebral origin, there is decided indication for local curative treatment much oftener than it is now resorted to in cases of insane women, either at asylums or in private practice."

Dr. Storer presented various evidence corroboratory of his views, and related an illustrative case. He also alluded to a peculiar sensational torpor of the insane as explanatory of the otherwise unaccountable fact that severe physical lesions, as fracture of ribs, &c., are not unfrequently discovered at post-mortem examinations of the insane, of which no complaint or suspicion had existed during life. From this he drew another deduction of practical importance in the administration of criminal law.

"4. In medico-legal investigations, whether they are coroner's inquests, trials for homicide, or for the abuse of insane patients in confinement, it must not be forgotten that the insane, so far as regards matters of sensation, whether as to effects from wounds or from acute or chronic disease, are not to be judged by the ordinary physiological laws."

Five hundred and thirty-second Meeting.

March 8, 1864. — MONTHLY MEETING.

The PRESIDENT in the chair.

The President called the attention of the Academy to the recent decease of three of its members; viz. Professor Edward Hitchcock of the Resident Fellows, and Baron Plana and Heinrich Rose of the Foreign Honorary Members.

The following papers were presented.

On the Right Ascension of the Pole Star, as determined from Observation. By TRUMAN HENRY SAFFORD, Assistant at the Observatory of Harvard College.

1. The fixed star α Ursæ Minoris, the Pole-Star, has been the object of very numerous observations, — more indeed than any other celes-

tial body, except, perhaps, the sun, the moon, and the principal exterior planets.

The reason is, that all observers of the northern hemisphere must depend upon it in a great degree to assure themselves of the position of their instruments.

Not only has this star been much observed, but many of the observations have been made serviceable for the determination of its position; whatever accuracy is possible in the place of a star should characterize the place of this. Nevertheless, there does not seem to be perfect security about its right-ascension; the different predictions of it given in different places do not harmonize so well with each other, or with observation, as might, perhaps, be expected. Thus, for example, the fifty-two consecutive transits which I have observed at the Harvard College Observatory (with the Simms meridian circle), in pursuance of the definitive plan mentioned in the Report of Professor Bond for 1862 (pp. 24–26), give the star's mean right ascension for 1863.0,

$$1^{\text{h}} 9^{\text{m}} 0^{\text{s}}.34,$$

or greater by $0^{\text{s}}.81$ than Wolfers's prediction in the *Berliner Astronomisches Jahrbuch* for that year, and greater by $1^{\text{s}}.22$ than that given in Dr. Gould's pamphlet, "Standard Places of Fundamental Stars, U. S. Coast Survey."

Reducing this back to 1860.0 by the proper motion now employed in the *Jahrbuch*, we have

Cambridge Observations, 1860.0	$1^{\text{h}} 8^{\text{m}} 3^{\text{s}}.464$	
Wolfers	"	"
Bessel – Zech (<i>Jahrbuch</i> for 1860)	2.654	Obs. — W. = $+0^{\text{s}}.81$
Gould (for 1860)	2.799	Obs. — B. Z. = $+0.66$
	2.32	Obs. — G. = $+1.14$

2. So far, then, as my own observations go, the earlier prediction of Bessel, the elements of which were determined in 1826, is more accurate than either of the later ones. It remains now to examine other observations made lately, to see if they concur in the same conclusion. One observer's work may be, and probably is, affected by a personal equation. We will compare Dr. Gould's tables of A. R. of Polaris, which extend from 1851 to 1863, with the observations made at Greenwich, Paris, and Cambridge, England, so far as the volumes containing them have reached us. To this will be added a comparison with Bessel's *Tabulæ Regiomontanæ*, as continued from the same elements by Professor Zech.

Comparison of Dr. Gould's Table of A. R. of Polaris with Observations.

	Observed.	Comp'd (G.)	O. — C.	Comp'd (Z.)	O. — C.
	h m s	s	s	s	s.
Greenwich 1851	1 5 19.02	18.66	+0.36	18.91	+0.11
1852	36.75	36.37	+0.38	36.64	+0.11
1853	54.65	54.19	+0.46	54.49	+0.16
1854	6 12.98	12.13	+0.85	12.45	+0.53
1855	30.86	30.19	+0.67	30.54	+0.32
1856	49.36	48.37	+0.99	48.74	+0.62
1857	7 7.37	6.68	+0.69	7.07	+0.30
1858	25.90	25.10	+0.80	25.52	+0.38
1859	44.23	43.65	+0.58	44.10	+0.13
1860	8 3.17	2.32	+0.85	2.80	+0.37
1861	21.50	21.13	+0.37	21.63	—0.13
Mean for 1856			+0.64		+0.26
Paris 1851	1 5 19.00		+0.34		+0.09
1852	37.09		+0.72		+0.45
1853	54.73		+0.54		+0.24
1854	6 13.55		+1.42		+1.10
1855					
1856	6 49.81		+1.44		+1.07
1857	7 7.62		+0.94		+0.55
1858	26.18		+1.08		+0.66
1859*	45.06		+1.41		+0.96
1860*	8 3.45		+1.13		+0.65
1861	22.56		+1.43		+0.93
Mean for 1856			+1.04		+0.67
Cambr. Eng. 1851	1 5 19.38		+0.72		+0.47
1852	36.68		+0.31		+0.04
1853	55.44		+1.25		+0.95
1854	6 12.39		+0.26		—0.06
Mean for 1853			+0.64		+0.35

3. There is evidently discrepancy enough between the tables and observation for further investigation. We have

	Correction of Dr. Gould.	Correction of Bessel.
Cambridge, Eng., 1853	+ 0°.64	+ 0°.35
Greenwich, 1856	+ 0.64	+ 0.26
Paris, 1856	+ 1.04	+ 0.67
Cambridge, Mass., 1863	+ 1.22	+ 0.66

All these numbers have the positive sign, and those referring to Dr. Gould's catalogue are the larger.

4. The mode of investigation which I have now adopted is to compare Bessel's *Tabulæ Regiomontanæ* with observations of Polaris made at different places during a little more than a century.

* See Erratum, p. 309 of the *Annales*, Vol. XVI. of the *Observations*.

I am not confident that I have included all the results which might be collected, although I have made a diligent search for them. But there are results from seventeen different observatories, some of them, as Greenwich, Paris, Dorpat, under several directors; and it is to be noticed that each one of the results in Table I. is derived from more than forty complete transits; in many cases, the number exceeds three hundred. No results have been excluded on account of discrepancy in the final combination of all.

In order to compress Table I. into smaller compass, I have combined several years' work of one observatory, in a somewhat similar manner to that used in §§ 2, 3. In many cases this has been already done by the astronomers themselves. The numbers given above for Cambridge in England, Greenwich, and Paris do not appear in Table I., as the corresponding observations are differently combined.

So far as I conveniently could, I have kept separate the work of different observers. This is not always practicable with the Greenwich, Paris, etc. observations. The names of astronomers in Roman in Table I. are those of the actual observers; those italicized are those of the directors, in cases where several observers employed the same instrument at about the same time.

The notes to Table I. give various details.

I have corrected the results reduced by the nutation-coefficient $8''.977$ to Peters's value $9''.223$, so far as the lunar nutation is concerned. The variation of the coefficients of aberration and solar nutation is so mixed with the errors arising from the effect of temperature on the instrument, that the precautions which eliminate the latter will also cause the former to disappear.

Table II. contains the corrections to be added to observations already reduced with the lunar nutation $8''.977$, to make the results accord with the value $9''.223$. The part of the correction common to all stars is omitted. The corrections for aberration and solar nutation have not been applied. These, it will be seen at once, are of different signs in different seasons.

The most conspicuous result of the comparison between Bessel's theory and observation is, that the former does, in fact, require a slight correction. This is not remarkable, as it was published about thirty-eight years ago. At that time the great majority of the observations here employed to correct it were not made, and Bessel adopted the wisest course *then* possible. He devoted a considerable portion of

his time for twelve years to the observation of this single star; the result of this was the position for 1820,*

$$0^h 57^m 1^s.505 \quad +88^\circ 20' 54''.27,$$

which, it will be seen, agrees nearly with observations of other astronomers. For the proper motion he compared this with Bradley's position (Bessel's own *second*† reduction), and from these two determined the A. R. and Dec. for every year from 1750 to 1850.

Like all Bessel's works, this has fully stood the test of time; the correction which now appears necessary can only be deduced by comparison with a great number of observations.

The other computations of the position and proper motion of Polaris to which allusion has been made are Wolfers's in the *Tabulæ Reductionum* and Dr. Gould's. The first agrees very closely with Bessel's. It is derived from a slightly different and more accurate reduction of Bradley's observations (the one employed in Table I., and cited in the notes), and from the mean of the best observations made about 1830. It does not, however, agree quite so well with observation as Bessel's.

The other one (Dr. Gould's) is also less accurate than Bessel's; both in A. R., for 1855.0, and in proper motion; in the former element its error is about double that of Bessel's, in the latter rather more.

The investigation (*Astr. Journal*, Vol. VI.) seems hardly complete. We miss in it Bessel's, Argelander's, Carlini's, and Henderson's observations; Airy's Cambridge determination, and, of those made under Struve's direction, the latter half of the Dorpat series (made by Preuss) and Schweizer's Pulcova observations; besides the long series made at Paris under Arago, and several others of less authority.

We must also regret that inaccuracies have crept in. Bradley's place for 1755 is wrongly reduced (by about 2^s of time) to 1855, and again in another place to 1850; to Piazz's for 1800, has been added about 3^s.6, which seems to be the "probable uncertainty" (*error verisimilis*) of a difference between Argelander and Piazz. Groombridge's for 1810 has been changed by 4^s.3 on account (it is stated) of the error of Groombridge's meridian mark. But this error had

* It will be seen in Table I. that I have given separately the results for 1817 and 1824, of the two transit instruments which Bessel then used.

† Using as for his own observations Lindenau's nutation.

already been in great part eliminated (for Polaris, at least) by Groombridge himself; for, of the ninety-three observations, forty-one* at least were taken below the pole. Such an error would have been exactly eliminated had one half of the observations been made below the pole.

There are some smaller discrepancies in the reduction to 1850, whose origin it is not easy to trace.

All the larger corrections to be made are of negative sign, and refer to the earlier part of the observations, so that, if they were made, the resulting proper motion would be larger algebraically; while the result for the mean of the dates for which the star's A. R. is correctly given, in the original investigation, would not be much altered, as the following numbers show.

$$B - G = 0^{\circ}.35 + 0^{\circ}.025 (t - 1855).$$

$$N - G = 0.64 + 0.037 (t - 1855).$$

B, G, N, denote respectively Bessel's, Dr. Gould's, and my own † A. R. of Polaris, for the time t , but referred to the equinox of 1855. In Table I. Δa denotes Bessel's discrepancy from observation; $\Delta' a$, Dr. Gould's; $\Delta'' a$, my own; C. — O. being taken of an opposite sign to the residuals of §§ 2, 3.

I have used Dr. Gould's formula, depending on the powers of the time. It is not, however, consistent with the trigonometrical computation from his own elements; which would deviate more largely from observation.

The sum of the squares of the discrepancies is,

For B, 12.88; excluding Piazzzi and Groombridge, 8.75

“ G, 21.91; “ “ “ “ 15.23

“ N, 10.30; “ “ “ “ 7.24

5. REMARKS UPON THE TABLES.

The authorities for the numbers in Table I. are generally well known; and the following remarks would enable any one to derive essentially the same results in detail as I have given.

* Philosophical Transactions for 1810.

† I have obtained by least squares, using the residuals in Table I., the correction $N - B = 0^{\circ}.29 + 0^{\circ}.012 (t - 1855)$. I did not think it expedient to use either Piazzzi or Groombridge here, on account of the doubt about the position of both their instruments. But they would have tended to make the discrepancy of N from G larger.

1755. — Bradley. I have used Peters's reduction of the A. R. of Polaris.

1785. — Maskelyne. The introduction of the known coefficient of nutation into Lindenau's conditional equations for this observer, as well as of L.'s own aberration and parallax, which are very accurate, enabled me to determine the A. R. from 1785, given in the Table with the proper motion $+0^{\circ}.065$ for the same date; which, reduced to 1855, is equal to $0^{\circ}.082$; a quantity sufficiently accurate to show that the progress of wear in the Greenwich transit-instrument would not affect our result seriously.

A trifling change (of about $0^{\circ}.04$) for the better in the representation of Bradley's observations would be made by omitting Maskelyne altogether.

1815, 1820. — Carlini. From the *Effemeridi Astronomiche de Milano*, 1821, p. 106 of the Appendix.

1817. — Bessel. Observations with the Dollond Transit, 1814–1819. *Tabulæ Regiomontanæ*, p. xliii.

1819. — Struve. *Observationes Dorpatenses*, III. liii. The latest tables of Bessel referred to are in Volume IV. of the Königsberg Observations. I have added $0^{\circ}.19$ to Struve's results, to refer them to his own later determination of the fundamental stars.

1824. — Bessel. *Loco modo citato*. Observations with the Reichenbach circle, 1820–28.

1824, 1832. — Dorpat (Struve and Preuss). See Peters's *Numerus Constans Nutationis*, p. 18. The quantity w was considered as the correction of A. R. for 1824, according to Struve, and $w + w'$ that for 1832, according to Preuss. Hence the values of Δa are the same as those of w and $w + w'$, with changed signs.

1830. Argelander's A. R. is given by Wolfers in his *Tabulæ Reductionum*, p. liii. I have no other knowledge about it save that it is manifestly very accurate.

1832. — Pond. I have preferred to employ the observations as given in the annual catalogues from 1829 to 1835, instead of the result of the catalogue for 1830. There is no appreciable difference of results; but there is some obscurity as to the reduction of the earlier observations. The result given for 1825 (1817–26) is (corrected for nutation) $0^{\text{h}} 58^{\text{m}} 15^{\text{s}}.83$, which accords well enough with Bessel's value, $0^{\text{h}} 58^{\text{m}} 15^{\text{s}}.49$.

1835. — S. Fernando. The mean of the results for 1834 and 1835, of three observers,

	Obs. — Bessel.
Montojo	— 1 ^s .12
Hoyos	+ 0.76
Marquez	+ 1.49
	+ 0.38

has been added to the place of the *Tabulæ Regiomontanæ* for 1835.

1840, 1850. — Paris. *Annales de l'Observatoire Impérial de Paris*. Observations, Tome II. p. xxxv. The observations from 1837 to 1845 were reduced to 1840, and those for 1846–1854 to 1850.

1840, 1845. — Berlin. The series in Vol. II. of the Berlin Observations, by Encke and Galle, gives for 1843 $\Delta \alpha = + 0^s.06$ (corrected for $\Delta \nu$),

$$\Delta' \alpha = + 0^s.03, \Delta'' \alpha = + 0^s.18.$$

1842, 1845. — Oxford. Mr. Lucas observed with the old transit instrument, and Mr. Johnson with the new one.

1843. — Doellen. I have not been able to find a copy of the Dorpat observations for 1841 and 1842, which also contain observations by this eminent astronomer.

1848. — Washington. The transit instrument gives, by thirty-seven double transits, $1^h 4^m 25^s.81$, and the meridian circle by forty-nine, $1^h 4^m 26^s.92$. I have simply taken the mean. The instruments seem both to be affected by temperature.

1855. — Carrington. Double transits alone. *Redhill Catalogue*, p. xxii.

1858. — Greenwich. Mr. Airy's new Catalogue of 2020 stars gives $1^h 8^m 3^s.05$, reduced to 1860. This would give $\Delta \alpha = - 0^s.26$; this does not include the result for 1861.

In order to justify the course which has been pursued, in determining the correction to Bessel's A. R., it is necessary to show that Bessel's declination is not largely erroneous. (See my paper in the *Memoirs of this Academy*, Vol. VIII. pp. 541 *et seqq.*)

The declination was computed from the place for 1755 in the *Fundamenta*, compared with Bessel's own for 1820. The correction for 1830 was $+ 0^s.03$ (Argelander in *Wolfers's Tabulæ Reductionum*, p. liii.) by seven series of observations; that for 1843 is $- 0^s.06$ (Peters in *Struve's Recueil des Memoires*, I. p. 201), and for 1850 and 1860 the Greenwich and Paris observations give, as compared with Bessel,

	Bessel - Zech.	Observed.	C. - O.
1850 Greenwich	88° 30' 34".90	35.09	— 0".19
1860 Paris	33 47 .07	47.23	— 0 .16
1860 Greenwich	33 47 .07	47.10	— 0 .03

No considerable correction seems necessary.

Table II. gives, for the years 1815–1860 inclusive, that part of the correction for the error of Lindenau's nutation, which is not eliminated in the clock-error. In applying it I have been careful to use the mean of the values taken from it for the years of observation, which sometimes extend over a large part of one revolution of the node. For this reason the number in the column $\Delta \nu$ opposite any given date in Table I. is not usually the result of Table II. for that year.

TABLE I.—*Comparison of Computed and Observed Right Ascensions of Polaris.*

			Computed.	Obs'd.	$\Delta \gamma$	$\Delta \alpha$	$\Delta' \alpha$	$\Delta'' \alpha$
			h m s	s	s	s	s	s
1755	Greenwich	Bradley	0 43 43.00	42.95		+0.05	+0.69	—0.61
1785	Greenwich	Maskelyne	49 18.20	17.66		+0.54	+1.10	+0.10
1800	Palermo	Piazz	52 25.94	25.30		+0.64	+1.12	+0.33
1810	Blackheath	Groombridge	54 39.84	37.56	+0.35	+1.93	+2.33	+1.72
1815	Milan	Carlini	55 49.66	49.32		+0.34	+0.65	+0.18
1817	Königsberg	Bessel	56 18.15	17.72	+0.28	+0.15	+0.47	+0.01
1819	Dorpat	Struve	56 46.97	46.68		+0.29	+0.59	+0.17
1820	Milan	Carlini	57 1.50	0.65	+0.56	+0.29	+0.58	+0.18
1824	Königsberg	Bessel	58 0.52	1.07	—0.01	—0.54	—0.31	—0.61
1824	Dorpat	Struve	58 0.52	0.27		+0.25	+0.48	+0.19
1830	Abo	Argelander	59 31.71	31.66		+0.05	+0.20	+0.04
1830	Cambr. E.	Airy	0 59 31.71	30.88		+0.83	+0.98	+0.82
1832	Dorpat	Preuss	1 0 2.85	3.44		—0.59	—0.47	—0.58
1832	Greenwich	Pond	0 2.85	2.31		+0.54	+0.66	+0.55
1835	S. Fernando	Cerquero	0 50.28	50.67	+0.25	—0.64	—0.57	—0.59
1838	Edinburgh	Wallace	1 38.59	38.21		+0.38	+0.40	+0.46
1840	Berlin	Encke	2 11.31	10.21	+0.54	+0.56	+0.54	+0.67
1840	Cambr. E.	Challis	2 11.31	10.73		+0.58	+0.56	+0.69
1840	Greenwich	Airy	2 11.31	10.93		+0.38	+0.36	+0.49
1840	Paris	Arago	2 11.31	11.10		+0.21	+0.19	+0.32
1842	Oxford	Lucas	2 44.44	45.23		—0.79	—0.85	—0.66
1843	Pulcova	Schweizer	3 1.17	1.91		—0.74	—0.82	—0.61
1843	Dorpat	Döllen	3 1.17	2.06	—0.10	—0.79	—0.87	—0.65
1845	Berlin	Galle	3 34.94	36.31	—0.42	—0.95	—1.07	—0.79
1845	Oxford	Johnson	3 34.94	35.26		—0.32	—0.44	—0.16
1845	Greenwich	Airy	3 34.94	34.35		+0.59	+0.47	+0.75
1848	Washingt'n	Maury	4 26.42	26.37		+0.05	—0.13	+0.25
1850	Greenwich	Airy	5 1.30	1.26		+0.04	—0.19	+0.27
1850	Cambr. E.	Challis	5 1.30	1.73		—0.43	—0.66	—0.20
1850	Paris	Arago	5 1.30	1.18		+0.12	—0.11	+0.35
1855	Redhill	Carrington	6 30.54	31.27		—0.73	—1.08	—0.44
1858	Greenwich	Airy	7 25.52	25.84		—0.32	—0.74	+0.01
1859	Paris	Le Verrier	7 44.10	44.90		—0.80	—1.25	—0.46
1863	Cambr. M.	Safford	1 8 59.68	60.34		—0.66	—1.22	—0.26

TABLE II.

Year.	$\Delta \nu$	Year.	$\Delta \nu$	Year.	$\Delta \nu$	Year.	$\Delta \nu$
s		s		s		s	
1815	-0.02	1827	-0.44	1839	+0.58	1851	-0.26
1816	+0.16	1828	-0.55	1840	+0.51	1852	-0.05
1817	+0.33	1829	-0.59	1841	+0.38	1853	+0.16
1818	+0.46	1830	-0.56	1842	+0.20	1854	+0.35
1819	+0.54	1831	-0.47	1843	0.00	1855	+0.50
1820	+0.56	1832	-0.34	1844	-0.20	1856	+0.60
1821	+0.52	1833	-0.14	1845	-0.38	1857	+0.63
1822	+0.41	1834	+0.06	1846	-0.52	1858	+0.59
1823	+0.26	1835	+0.26	1847	-0.60	1859	+0.48
1824	+0.08	1836	+0.42	1848	-0.62	1860	+0.32
1825	-0.11	1837	+0.53	1849	-0.54		
1826	-0.28	1838	+0.59	1850	-0.43		

On a Process of Organic Elementary Analysis, by Combustion in a Stream of Oxygen Gas. By C. M. WARREN.

The process in general use for ultimate organic analysis had seemed to me so nearly perfect as to leave little room for any very marked improvement. Like all other processes of analysis, however, it has its own peculiar sources of error, inherent in the nature of the substances employed, and in the manipulations to be performed. But these appear to have been reduced to a minimum; so that, with great care and the necessary skill, there can be no reason to doubt that that process, with the various modifications which have been proposed to meet special cases, is capable of affording as accurate results, in a majority of instances, as can, perhaps, be claimed for any other analytical process. Nevertheless, there are instances, and they are doubtless numerous, where so satisfactory a solution of the question which may be under consideration as would be highly desirable, cannot be attained by that process. It was after repeated unsuccessful efforts, in a case which appeared to be of this kind, that I was led to conceive the idea of making the combustion in oxygen gas alone; and to devise the method which I am about to describe.

Were it not for the danger of explosions in the combustion tube, the occurrence of which would, at least, render its use fruitless of good results, the employment of pure oxygen, as a combustion agent in analysis, would seem, of all substances, the one most naturally suggested. This apparent difficulty is probably the chief reason it has not long ago been brought into general use; its employment since the time of Prout, so

far as I am informed, having been mostly confined to the combustion of the residual carbon of highly carbonaceous substances, after the other decomposition products, containing the hydrogen, had been burnt at the expense of oxide of copper.

By a very simple device I entirely obviate the danger of explosion ; viz. the combustion tube is closely packed with asbestos, or other inert substance,* and yet so loosely as to leave free passage for gases through the interstices. The packing of the tube requires some care. This, however, may be readily accomplished, giving great uniformity to the mass of asbestos, by having the latter carefully broken into small, loose pieces, which are gradually added to the tube, and arranged in position by means of a stiff iron wire. Little attention need be had to the packing of the centre of the tube, as this will come right of itself, if the packing against the sides is properly done. It will be found convenient and expeditious to turn the tube continuously in the hand, and cause the end of the iron rod to follow around against the sides of the tube, placing the asbestos, by gentle taps, alongside its inner surface, so that only very small open spaces may be seen.

In the experiments which I have made I have generally had about ten or twelve inches in length of the tube filled with asbestos. As the combustion takes place within a very short space, it seemed at first that the tube might be reduced considerably below the ordinary length ; it was found, however, that shortening of the tube below a certain limit made it difficult to control the distillation of volatile substances and prevent too rapid combustion ; it being essential in this, as in other processes, that the combustion should proceed slowly, and with a good degree of regularity ; otherwise it would be difficult to regulate the supply of oxygen to meet the demand of the burning substance. By

* I have used only asbestos in my experiments thus far, and in every instance with perfect success. Quartz sand, selected with care as to the size of the grains, had suggested itself, on account of greater convenience in filling the tube, as it would properly arrange itself on simply being poured into the tube. It would, however, be liable to the objection, that any jarring of the tube, while lying upon the combustion furnace, would be likely to settle the particles more closely together, and form a channel along the top, in which an explosion might take place which would spoil the analysis. I therefore prefer asbestos to anything which I have thought of ; and any apparent inconvenience in preparing a tube with this substance will pass into insignificance, if the precautions which I advise for protecting the tube from breakage are observed, as then the same tube may be made to last for a long time.

having the column of asbestos of considerable length, the anterior end of which only is ignited, the substance, if volatile, becomes diffused through a large space, and the distillation thereby easily controlled; as only a small portion of the substance need then be heated at a time. Doubtless a shorter tube would answer equally well for many non-volatile substances. It will be observed that the asbestos packing is but another application of the principle involved in the use of wire gauze in Davy's safety-lamp.*

In order to obtain perfect control of the analysis, and to be always certain that the requisite quantity of oxygen is being admitted, I have adopted certain simple expedients, enumerated below, which have been found fully adequate to that end.

1. The distillation of the substance, if volatile, is effected by means of a bar of copper, placed over and attached to one of Bunsen's burners, as shown at *a*, in the accompanying figure.

This bar, having first been brought to the maximum temperature which the lamp is capable of producing, is placed near or under the bulb containing the substance; applying that part of the bar nearest or most remote from the flame, or an intermediate point, according to the temperature required.

The steadiness of the heat thus applied, and the facility with which it may be regulated, by simply moving the bar, render it decidedly preferable to any other means which I have employed for that purpose. I had for a long time used such a bar for the same purpose in the old process, with extreme satisfaction. In some cases a bar of copper laid on the combustion furnace,† one end projecting into the flame by which

* It has occurred to me that my safety-tube may serve as the basis of a more simple and equally accurate process for the analysis of gases, by gradual combustion, instead of explosion; in which weighing would take the place of measurement. I propose, at an early day, to study this question by a series of experiments.

† As there are those, and probably there are many, who still persist in the use of charcoal in place of the more modern gas furnaces for generating heat for combustions, I desire here to say that I have in use one of Baumhauer's gas furnaces, procured a few years ago from Luhme & Co., in Berlin, which seems to me to have no fault. It is impossible for me to conceive what objection one could have to it, unless it be that a naked tube might become overheated along the bottom; and this would be a valid objection if the remedy were not so simple. If the tube be taid in a trough of sheet iron (brass is objectionable, in my process, on account of its obscuring the tube with oxide of zinc), with a thin layer of asbestos between, and fastened together with wire, no harm can ever occur from overheating. A

the tube is being heated, and the other end raised and extending towards the substance, has been found to answer a good purpose.

2. In the case of volatile bodies (I have not yet analyzed any others by this process), I have found the combustion to proceed most satisfactorily when, having first heated about four or five inches of the anterior portion of the tube, which includes the oxide of copper, and started the flow of oxygen, I apply the heated bar to the bulb containing the substance, and immediately expel the whole of the liquid, — which becomes at once absorbed by the asbestos, — and then, if necessary, gradually move the heated bar forward, driving the substance towards the ignited portion of the tube, until it shall have reached that point in the tube where the temperature is just sufficient to cause the oxygen to take up the vapor in suitable proportion; indicated by the bubbles of oxygen and carbonic acid, as will be described below: — a point as easily found as to find, in the old process, the requisite temperature for proper distillation of the substance. When this is accomplished, which will occupy but a short time, the heat in front of and behind the substance being constant and uniform, no further manipulation of the heat is re-

tube of Bohemian glass, thus protected, may be used for a large number of analyses; and, indeed, become almost a permanent fixture upon the furnace. The asbestos prevents the glass and metal from adhering together, — which is probably the chief or only cause of breakage of wrapped tubes, — so that sudden cooling and re-heating may take place with perfect security. It is important that the iron trough should not extend much backward of that part of the tube where it is desired that the combustion should take place, so that the temperature of the principal part of the column of asbestos may remain under the control of the operator, by means of the heated copper bar, or otherwise.

Independent of the use of a metallic bar, as described above, or any novel appliance, the heat can be regulated by this furnace with as great, or even greater nicety than by the use of coal. The partitions in this furnace, between the cocks, are two inches apart; so that the gas from one of the jets ignites about two inches of the tube. To rely, therefore, alone upon the cocks for regulating the heat in burning the substance, would doubtless often lead to bad results; but the heat may be made to approach the substance in the most gradual manner, — next to that of conduction by a metallic bar, — by making use of a piece of thin brass plate, about two inches long, and half an inch wider than the top of the furnace, the edges of which are turned down against the sides.

If this plate is laid on the wire gauze covering the furnace, and pressed down so as to fit closely enough to prevent the gas from igniting under it, the gas escaping from the cock underneath may all be made to burn at one end of the plate, and to extend the heat along the tube as gradually as the plate itself is capable of being moved.

quired; the supply of oxygen only requiring attention. In the ordinary way, on the contrary, in which the heat is applied only on one side of the substance, the latter, if volatile, is constantly changing position backward in the tube, necessitating a corresponding movement of the heat in the same direction; which requires constant care and considerable skill.

This procedure — referring to the immediate expulsion of liquid from the bulb, etc. — implies that that portion of the tube immediately forward of the bulb should not already be too warm, which might easily be the case with a body of very low boiling-point. It would then be necessary to expel the substance from the bulb no faster than the oxygen would absorb it in the proper proportion; which, as experience has shown, may be easily accomplished.

With a body of extreme volatility it may be also necessary to place a dish containing pieces of ice under the bulb; as even the temperature of the surrounding air might in such a case cause the substance to pass forward too rapidly.

3. The oxygen is admitted through Liebig's potash bulbs containing sulphuric acid; and the carbonic acid formed is absorbed by similar bulbs with potash; to which is attached a tube filled with soda-lime and chloride of calcium, as recommended by Mulder,* to take up any traces of carbonic acid which may escape absorption in the bulbs, and the trace of moisture which is invariably carried forward from the latter. Special care should be taken to select both sets of bulbs with the view to have the openings in the one as nearly as may be of the same size as those of the other, so that the bubbles of oxygen, considered as representing volumes, entering the sulphuric acid bulbs, may be readily compared with the bubbles or volumes of carbonic acid entering the potash bulbs; these bubbles may then serve as a valuable index by which to regulate the supply of oxygen. Especially is this true in cases where the composition of the body to be analyzed is pretty nearly known, as then the number of bubbles of oxygen required for every bubble of carbonic acid produced may be readily calculated.

But as it is, in any case, advisable to conduct the experiment so that there shall always be an excess of oxygen passing unabsorbed through the potash bulbs, and as this excess would seldom be large even

* Liebig and Kopp's Jahresbericht, 1858, p. 588.

if a sufficiency of oxygen were admitted to burn the most richly hydrogenized body known, it may generally be well to admit enough for such a case.

The volume of oxygen actually consumed in burning the lightest liquid known — probably of the formula $C_8 H_{10}$ — which I have separated from petroleum, and which contains a larger percentage of hydrogen than any other non-gaseous body, as compared with the volume of carbonic acid formed, is as 1.62 : 1 ; the fraction representing the oxygen which is taken up by the hydrogen of the body, and which of course becomes condensed and disappears from the volume of carbonic acid. In burning this body with just the equivalent quantity of oxygen, — assuming that the combustion would be complete under such circumstances, — we should have one bubble or volume of carbonic acid entering the potash bulbs for every 1.62 bubbles or volumes of oxygen entering the sulphuric acid bulbs. A sufficient excess of oxygen would be secured in this case, and a simple ratio obtained, if 2 bubbles of oxygen were to be admitted for 1 bubble of carbonic acid appearing in the potash bulbs. The case would then be further simplified by having the openings in the sulphuric acid bulbs of such size as would give bubbles twice as large as those from the potash bulbs ; as then, when the bubbling should be equally rapid in both, the relation between the volumes of the gases would still be maintained, viz. 2 vols. of oxygen to 1 vol. of carbonic acid. Such bulbs would be highly desirable, but would probably have to be made expressly for the purpose.

4. As an additional control over the supply of oxygen, and serving also as a temporary safeguard against the escape of incompletely oxidized substance, in case of too rapid distillation, with an insufficient flow of oxygen, I have two or three inches in length of the tube filled with coarse, strongly ignited oxide of copper, placed in front of the asbestos, and this followed by a plug of the latter substance to keep it in place, and prevent the formation of a channel along the upper surface of the oxide of copper. The tube itself being laid in an iron trough, as above described, with the upper half of the tube exposed, the oxide of copper is heated in such a manner that any reduction would be readily observed at the end in contact with the asbestos. In this manner it serves as a valuable indicator, by which to determine, at a glance, whether the flow of oxygen is sufficient. It will rarely happen that any reduction of the oxide of copper will take place. I have, however, in some of my earlier experiments, with too short a column of asbestos,

and ill-adapted bulbs, had so much of the oxide of copper reduced that combustible gasses passed through the absorbing apparatus; and in one instance, when the unabsorbed gases were collected, the quantity of combustible gas was so considerable as to form, with the oxygen collected with it, — which of course came forward at an earlier or later stage of the process, — an explosive mixture. Having seen no indications that any other than gaseous bodies escaped the combustion tube in such a case, it occurred to me that such an analysis might be saved by collecting the gas over mercury, and, at the close of the combustion, before detaching the absorbing apparatus, conducting it a second time through the combustion tube.* As a matter of economy, also, in the saving of the excess of oxygen, when a considerable number of analyses are to be made, this idea seemed to recommend itself; as the oxygen would, at the same time, become purified from any traces of combustible matter which might be present, and could then safely be collected as pure oxygen, and finally transferred to the oxygen gasometer.

I therefore constructed for this purpose the apparatus which is represented in the background of the accompanying figure as attached to the anterior end of the absorption apparatus. At the close of the combustion, when only pure oxygen appears to enter the potash bulbs, the flow of oxygen is interrupted; the communication with that portion of the drying apparatus which is back of the short U tube, *A*, is closed at *b*; and the tube *B* — which is movable in the cork — turned up.† The joint at *c* is then disconnected; the end leading to the receiver *C* tightly closed with a piece of glass rod; and a communication established between the absorption apparatus and another receiver containing water, — not shown in the figure, — for collecting the pure oxygen. On opening the spring-clip *d* (the more modern form, which is provided with a fine screw, is excellently well adapted for this purpose), the mercury will flow from the reservoir *D* into the receiver *C*, and force

* As the time consumed in an experiment is so short, and the quantity of combustible gas present, if any, so very small, and that mixed with a very large quantity of oxygen, it is not improbable that the gas might as well be collected over water; as the quantity which could be absorbed by the water in so short a space of time would probably be inappreciable.

† That this tube may not operate as a siphon, the outer limb is formed by attaching, near the bend, a flexible tube, of larger bore than that of the glass tube. This flexible tube is preferable to glass, on account of the readiness with which it adapts itself to any change of position of the glass tube, by which it may always project into the receiver underneath, and prevent waste of mercury.

the gas through the capillary tube *ee*; thence through the short U tube *A*, containing chloride of calcium, to the combustion tube and absorption apparatus; and the gas is finally collected over water in the receiver provided for that purpose.

The introduction of a longer column of oxide of copper would probably accomplish the same purpose with less expense; but neither expedient can be regarded as essential to the process. As the saving of an analysis by the use of a longer column of oxide of copper would only be occasional, the additional heat required, and consequent discomfort occasioned by its continued use, would hardly be compensated for. So that, while I would not, therefore, recommend the use of an additional quantity of oxide of copper, I would also discard the other expedient of collecting the gas over mercury or water, etc., unless the saving of the surplus oxygen, together with the additional security afforded, should be considered of sufficient importance to recommend it. As the passing through of the gas the second time requires no attention after it is once started, and occupies but a short time, during which the operator may attend to anything else, I much prefer, for myself, to retain in use that part of the process.

5. Some other less important peculiarities in the construction and use of the apparatus will now be noticed, in connection with some remarks on the performance of the analysis.

The posterior end of the combustion tube, as seen in the figure, is bent obliquely upward, as in the common form, except that, instead of being drawn out to a point, it is left of the full size of the tube. The object of this form is to prevent, in a great measure, the escape of oxygen during the time occupied in introducing the substance for analysis; and also for greater convenience and security from loss in the performance of this operation; especially in the case of volatile liquids. In the latter case, the neck of the bulb — which has previously been provided with one or more scratches on its side near the end — is introduced into the end of the combustion tube, and broken off by pressure against the side of the tube; the bulb itself is then allowed to drop in, and the end of the tube immediately closed with a perforated cork containing a glass tube, *f*, connecting it with the drying apparatus. This connecting tube is constructed of hard Bohemian glass; the anterior end of which is drawn out to a short, blunt point, and the opening nearly closed in the blowpipe flame, to the size of a small needle; the object of which is, to increase the rapidity of the flow of

oxygen at that point, and thereby diminish the liability to loss from diffusion of gases or vapor backward into the drying apparatus, which is always too liable to occur when the posterior end of the combustion tube is not sealed.

As an additional precaution against loss from this source, this connecting tube is packed with asbestos in the same manner as the combustion tube; and during the combustion is heated with one of Bunsen's burners. In case vapor of the substance should reach this tube, notwithstanding the above precaution against it, it could not reach the drying apparatus as such; but would be immediately decomposed, and the carbonic acid formed would at least stand a good chance of being carried forward, and prevent a loss in the determination of the carbon. The heating of this connecting tube may be superfluous for the object above described (a point which I have not yet taken the time to determine); but it certainly has the good effect of heating the oxygen, and thus preventing the condensation of liquid at the cork in the end of the combustion tube.

In the performance of an analysis, the first step should be to expel the moisture from the combustion tube, while hot, by passing through it, for some time, a stream of dry air from the gasometer.* The tube should then be filled with oxygen, before the substance, if volatile, is added; as otherwise particles of unburnt substance might escape during the displacement of the air, and occasion loss. The absorbing apparatus, having been previously weighed, is then attached, and, if the excess of oxygen employed is to be saved, the oxygen again admitted to expel the air from the absorbing apparatus. The connection is then made with the receiver *C*, if used, and the tightness of the joints tested by turning down the tube *B*, so as to partially exhaust the apparatus.

* The necessity for this may be entirely obviated, after the first analysis, and much time saved and uncertainty avoided, by connecting the anterior end of the combustion tube, at the close of a day's operations, with a set of stationary drying tubes of ample capacity, which may stand back of the furnace out of the way, communication with which is established by means of a flexible tube. Or, better, a movable tube may be attached by means of a screw to the opening in the top of the gasometer, extending to the top of the upper reservoir, so that water cannot enter, and then, by simply turning the cock underneath, communication would be opened between the surrounding air and the combustion tube, through the intervening drying apparatus. At the close of work the anterior end of the combustion tube should then be tightly corked, the fire extinguished, and the tube allowed to cool in dry air. It would thus be always ready for immediate use.

If found tight, as indicated by the liquid in the potash bulbs, the tube *B* is again turned up, and the substance then introduced in the manner above described. A very slow stream of oxygen is now admitted; the tube *B* again turned down till the level of mercury in this tube shall be half an inch to an inch below the level of mercury in the receiver *C*; and from time to time during the combustion the position of this tube is adjusted so as to preserve about this difference between the levels of the mercury, or at least so as to prevent the mercury in the tube from ever rising above that in the receiver.

In this manner the mercury, instead of offering resistance to the passage of gas from the combustion apparatus, and thus increasing the internal pressure upon the joints, which would be objectionable, actually operates advantageously by producing partial exhaustion, and thus diminishing the internal pressure upon the joints, and consequently the liability to leakage. The distillation of the substance is now commenced, and conducted as previously detailed above. So soon as condensation of moisture appears in the neck of the chloride of calcium tube, indicating that combustion has commenced, the flow of oxygen may be gradually accelerated to keep pace with the progress of the combustion, as indicated by the bubbles in the potash bulbs. When the burning of the substance seems to have been completed, heat is gradually applied, for a short time, along the whole length of the column of asbestos, to obviate the possibility of any loss from unburnt substance.

The absorbing apparatus may be weighed filled with either oxygen or air; for myself, I prefer the latter, as, on the whole, more convenient and less liable to lead to error. At the close of the analysis, therefore, I expel the oxygen from the apparatus by admitting air from the air-gasometer,* saving for further use the oxygen which is expelled during

* The oxygen-gasometer and the air-gasometer each having a separate drying apparatus, the time consumed in changing from one to the other is very much shortened, as the necessity for displacement of the oxygen or air — as the case may be — which is contained in the drying apparatus is avoided. Each drying apparatus consists, 1st, of Liebig's bulbs, containing sulphuric acid; 2d, of a U tube, 15 inches high (nearly 3 feet of tube), filled with soda-lime for carbonic acid; and, 3d, of two such U tubes (5 to 6 feet of tube), filled with chloride of calcium. The object in using drying tubes of such large dimensions is to avoid the necessity of too frequent renewal. The gasometers stand in a pan of copper, which is provided with an outlet to the sink, so that they may be filled without disconnecting from the drying apparatus; thus giving a degree of permanence to the apparatus and saving some labor.

the first five or six minutes. Thus far I have applied this process only in the analysis of volatile hydrocarbons of the formula $C_n H_{n-6}$; $C_n H_{n+2}$, etc.* As a mixture of the vapors of these bodies with oxygen is highly explosive, a more severe test of the safety of the process could not be applied.

In *every* experiment which I have made, the combustion has proceeded as quietly as if burning in the open air. The results obtained are extremely accurate and uniform.

Although the bodies which I have analyzed represent but a single class of organic substances, I can see no reason to doubt that the process will apply equally well in the generality of cases.

If this view be corroborated by actual experiment, the process can hardly fail to supplant the common methods; if for no other reasons than its greater convenience, economy of time, avoidance of excessive heat, neatness, etc.; while, as regards accuracy of results, it will, at least, not be found inferior to the other methods; but, on the contrary, I think preferable, as affording greater security against failures and errors from accidental causes.

Having obtained such satisfactory results in the cases referred to, and being prevented by other important work, to which the study of this process is only incidental, from pursuing the subject further at present (except so far as I shall have occasion to use the process in my other investigations), I have thought it advisable to present the process to the Academy as it now stands. I hope, however, before long to be able to resume the work, with the view to determine, by experiment, the extent of its applicability as a general method, and will report the results to the Academy.

* In an analysis of amyl-alcohol, made in my laboratory by my friend Mr. Storer, for the sake of familiarizing himself with the process, — it being his first analysis by this apparatus, — the following result was obtained.

	Experiment.	Theory.
Carbon, . . .	68.53	68.18
Hydrogen, . .	13.63	13.64

Five Hundred and Thirty-third Meeting.

April 12, 1864. — MONTHLY MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read letters relative to exchanges; also, letters from Professor Thomas Graham of London, Professor Max Müller of Oxford, Dean Milman, Professor J. P. Lesley of Philadelphia, Professor Ogden N. Rood of Columbia College, Major-General George G. Meade, Mr. Edward Pearce, and Dr. William Watson, in acknowledgment of their election into the Academy.

Mr. J. A. Lowell presented informally and read a report from the Committee on the Revision of the Statutes, recommending certain amendments. The report was laid on the table, to be taken up for action at the Annual Meeting.

Professor Rogers, from the committee on the subject, read for information of the Academy a digest of the proposed additions to the Standing Votes.

It was moved by Dr. B. A. Gould, "That the several portions of the Proceedings of the Academy be distributed by mail to the Fellows and Members, whenever ready for distribution." It was ordered that this motion be brought up at the Annual Meeting.

Mr. Safford presented a Memoir by Mr. G. W. Hill on the Great Comet of 1858.

Dr. Dean exhibited some photo-lithographic representations of the *medulla oblongata*; being illustrations of his memoir upon the subject, recently published by the Smithsonian Institution.

The President presented a Memoir by Professor Treadwell, "On the Construction of Hooped Cannon,—being a Sequel to the Memoir on the Construction of Cannon of great Caliber, &c., published in the Sixth Volume of the Memoirs of the Academy."

Professor Tuckerman presented the following paper:—

OBSERVATIONES LICHENOLOGICÆ. *Observations on North American and other Lichenes.* By EDWARD TUCKERMAN, A. M.
(Continued from Vol. V. p. 422.)

COLLEMA LEPTALEUM, sp. nov.: thallo membranaceo-cartilagineo suborbiculari lobato-plicato fenestrato-lacero margine elevato rugoso-granulato e læte-iridi obscuriore subtus pallido; apotheciis majusculis planis disco e castaneo nigricante margine tenui evanido. Sp. in thecis oblongo-clavatis 6–8næ, vermiformi-bacillares apicibus obtusis, rectiusculæ, 4–12-blastæ, diam. 8–14° demum 20° longiores. On trunks, not uncommon from New England to Virginia. New York, *Mr. Russell*. South Carolina, *Mr. Ravenel*. Alabama, *Mr. Peters*. Louisiana, *Dr. Hale*. Island of Cuba, *Mr. Wright*. Long regarded by me as identical with that state of *C. fasciculare*, Ach., which constitutes *C. aggregatum*, Nyl., but differing from the European lichen (Fr. Lich. Suec. n. 50. Moug. & Nestl. Cr. Vog. n. 453) in its smaller, narrower spores, no less than in its better-developed fronds. In the latter respect, *C. implicatum*, Nyl. (Lindig. Lich. N. Gran. n. 749) rivals, and is indeed much like it, but the spores are more diverse than those of *C. aggregatum*.

TRACHYLIA CALIFORNICA, sp. nov.: thallo crustaceo gyroso-plicato superficie rimuloso-ruguloso ambitu lobato glaucescente; apotheciis in verrucis thallinis majusculis mastoideis innatis disco subplano nigro margine albido sub-obsoleto. Sp. in thecis lineari-elongatis octonæ, obtusissime ellipsoideæ, diblastæ, medio demum constrictæ, obscure fuscæ, diametro subduplo longiores. On metamorphic sandstone rocks, Oakland hills, California, *Mr. H. N. Bolander*. May be considered, as respects the thallus, the most remarkable species of the genus. The granules of *T. lucida*, Th. Fr., become indeed scale-like, and those of *T. tympanella* pass at length into a more or less distinctly plaited crust; but the thallus of the present is originally plaited, and the lobation of its circumference is as distinct as, and resembles, that of *Lecidea* (*Thaloidima*) *candida*, (Web.) Ach., with which species, and *L. mamillaris*, it also agrees in the minute wrinkling, looking often like mealiness, of the surface. Apothecia immersed in conoid-hemispherical warts (about half a line in diameter at the base and often a little exceeding that in height); the flattish, black disk, scarcely a little grayish under a glass, appearing as if bordered only by the very white edge of the thalline receptacle. Examined, however, with a more powerful lens, this edge

is found to include, or often conceal, a white or whitish true margin, not containing gonidia, and appearing to belong to the proper exciple, (but compare here the observations of Koerber, Parerg., p. 286,) being traceable, in a vertical section, if I do not greatly mistake, downward to the base of the apothecium; which is, in that case, not lecideine (as is assumed or asserted, by several writers, of the exciple of *Trachylia*), but biatorine. And this biatorine structure appears, indeed, unquestionable in *T. tigrillaris*, the apothecia of which (often conditioned by the thallus similarly to those of the present), though finally and commonly black, and so described by all writers (Turner and Borrer observing, however, Lich. Brit., p. 133, that the wall of the exciple, seen in section, is "not black but grayish," to which reference will again be made below), occur also in Lapland specimens collected by Wahlenberg, and in others from this neighborhood, brownish, and even whitish, both externally and in section. Nor does there seem to be any difference of color, in a section of the palest of these apothecia between the base (hypothecium) and the margin; but, as the exciple blackens above, a very thin continuous line of the same color is observable also below, and, within this, the more conspicuous white layer, extending also upwards, to which we have already referred. And this double hypothecium, variously modified, appears in fact characteristic of *Trachylia*, as a genus. It is seen in *T. Californica* (showing in section a white hypothecial layer, and below that a thicker blackish-brown one, disappearing, or at least the color, below the excipular margin), and is marked in *T. tympanella* (where the white layer is readily traceable into the powdery inner border characterizing that and other species, as indicated in Acharius's figure, Lichenogr. t. 3, f. 1, while the much-thickened, dark-brown or blackish, inferior layer forms the outer, black one), with which last *T. lecideina*, Nyl. (Lich. Par. n. 18), *T. stigonella* (Moug. & Nestl. Cr. Vog. n. 858), and *T. lucida* (Th. Fr.) sufficiently agree; and the structure is also the same in *T. leucampyx*, Tuckerm. (Wright. Lich. Cub. n. 21), a species especially remarkable for the prominence of the white margin, which finally overlays and conceals the proper black one, as well as in *T. javanica*, (M. & V. d. B.) Nyl. (Lich. Cub. n. 22), in which the white layer is reduced to a mere film, and the black exciple has its most extraordinary development. The view of the structure of the exciple of *Acolium ocellatum*, Koerb. (*Trachylia*, Flot.), otherwise unknown to me, taken in the learned author's exhaustive description (Parerg. pp. 285, 286),

has been already cited, and should be compared with that which I have ventured to prefer; but it may be added that no other species appears so fully illustrative of the present one.

STEREOCAULON PILOPHOROIDES, sp. nov.: podetiis elatis erectis validis simpliciusculis apicem versus parce ramosis ruguloso-subcorticatis etomentosis albidis phyllocladiis e verrucæformi dein subelongatis exasperatis; apotheciis terminalibus mediocribus disco mox semigloboso nigro margine albido flexuoso-irregulari. Cephalodia scrobiculato-foveolata, granulis gonimis in nodulis cylindræis irregulariter dispositis. Sp. in thecis oblongo-clavatis octonæ, e fusiformi acicularæ, 4-10-blastæ, diam. 10-24° longiores. Spermatia acicularia, falcato-curvata, sterigmatibus simplicibus. Sandwich Islands, *Dr. W. Hillebrand*. With the aspect of *Pilophorus*, but the apothecia, spores, and spermatia of *Stereocaulon*; in which genus it belongs to the neighborhood of *S. ramulosum*. Podetia four to five inches high, stout but brittle, dividing into two or three long branches above the middle, which part distichously, or send out irregularly, short branchlets terminated by the subglobose, black apothecia. Phyllocladia more or less confluent, especially above, but passing into *papillæ*, which towards the base are elongated and terete. The thin hypothecium is blackish-brown; the thalamium proper less colored, with filiform, sometimes branched, brown-headed paraphyses.

PLACODIUM CLADODES, sp. nov.: thallo erecto dichotomo-ramoso ramis teretibus fastigiatis in crustam papillatam aurantiacam cæspitosostipatis; apotheciis sub-mediocribus sessilibus disco plano pulverulento fulvescente submarginato, margine thallino demum crenulato. Sp. in thecis brevibus saccato-oblongis singulæ, mediocres, incolores, obtuse ellipsoideæ, diblastæ, diam. subduplo longiores. On the earth, in the alpine regions of the Rocky Mountains, *Mr. E. Hall*. Apparently crustaceous, but in fact fruticulose, and, so far as I am aware, the first distinct indication of that type of thallus in the yellow, Parmeliaceous Lichens with bilocular spores. Thallus of the lichen before us rather exceeding (in the specimens, which do not show the organic or other *substratum* upon which it grows) a quarter of an inch in height; the erect branches solid, not very fragile, terete, much and fastigiatey branched, and closely crowded together, blackish at the base, but becoming paler above, where they pass into the papillæform branchlets which constitute the crust-like, warted, orange-yellow surface. Apothecia a little darker than the crust, powdery, the disk sometimes margi-

nate; the thalline border somewhat entire, or at length more or less crenulate. Paraphyses rather stout, branching, especially towards the thickened yellowish summits. Spore-sacks short, oblong, never appearing to contain more than a single spore, which varies from roundish to ovoid, and at length obtuse-ellipsoid; the contents very often irregularly disposed, but passing at length into two approximated sporoblasts, scarcely showing any trace of an isthmus. Spermatogones indicated by their darker-colored ostioles; spermatia very minute, short, appearing to be ellipsoid, or a little oblong.

PLACODIUM PHEUM, sp. nov.: thallo subcartilagineo lævigato mox interrupto subareolato viridi-glaucescente hypothallo nigro prominente; apotheciis sessilibus biatorinis plano-convexulis disco fusco margine integerrimo sub-concolore. Sp. parvulae, incolores ovoideo-ellipsoideae, polari-diblastae, diam. $1\frac{1}{2}$ – $2\frac{1}{2}^{\circ}$ longiores. *Lecanora*, Tuckerm. in Wright Lich. Cub. n. 112. On calcareous rocks in the island of Cuba, *Mr. Wright*. The colors well distinguish this lichen, which is scarcely comparable with any other of the group known to me.

LECANORA (*Squamaria*) *BOLANDER*, sp. nov.: thallo caespitoso dichotomo-ramosissimo viridi-stramineo, ramis teretibus fastigiatis, extremis papillaeformibus obtusis; apotheciis mediocribus terminalibus sessilibus disco e carneo-luteolo fulvescente nudo, margine thallino tumido integro. Sp. octonae in thecis clavatis, incolores, mediocres, ovoideo-ellipsoideae, simplices, limbatae, sporobl. dein variabili, diam. $1\frac{1}{2}$ – $2\frac{1}{2}^{\circ}$ longiores. Spermatia acicularia, arcuata, sterigmatibus simplicibus infixa. On rocks ("metamorphic sandstone") in Marin county, California, *Mr. H. N. Bolander*. Comparable, as respects the colors and size, with *L. rubina*, but differing remarkably in its fruticulose thallus, which is divided much as that of *L. fruticulosa*, Eversm., from the Kirguis steppes. Sods irregularly rounded, and not much exceeding an inch in diameter; a central trunk dichotomously dividing into thickish, short branches, (cartilagineous and greenish straw-colored without, and with a densely compacted, white medullary layer,) which pass at the summits into obtuse *papillae*. Apothecia not unlike those of *L. rubina*, except in the persistently thicker margin, and the lighter-colored disk. The present and two following species are associable with *Squamaria*, Nyl. (*Placodium* (Massal.) Th. Fr.),—a group undistinguishable, however, from *Lecanora* (as compare Nyl. Lich. And. Boliv. in Ann. Sci. 4. 15, p. 377, note) except by the more or less effigurate thallus.

This type of frond (intermediate, apparently, between the foliaceous and the crustaceous) is in fact nearest to the latter, and often most manifestly a modification of it, and its systematic value has, it appears to me, been well subordinated by Dr. Stützenberger (Beitr. z. Flechtensyst. in loco.)

LECANORA (Squamaria) HAYDENI, sp. nov.: thallo subfoliaceo crassiusculo coriaceo-cartilagineo lacero-laciniato viridi-stramineo subtus rufo-fuscescente ambitu nigricante, laciniis lobato-divisis margine albo-crenulatis convolutis; apotheciis. . . . Upon the earth, Laramie plains, Nebraska, *Dr. F. V. Hayden*. "Covers the ground," says Dr. Hayden, in a letter of 28th December, 1861, "in many parts of the West, especially where there is much gypsum in the soil. In the Laramie plains it covered many square miles, in most places detached and blown about by the wind, sometimes even drifted. It is found *in situ* where the ground is moist, where it is most abundant oftentimes; there is no wood or rocks for it to be attached to." Agreeing in its remarkable history with *Lecanora esculenta*, (Pall.) Eversm., of the Asiatic and African deserts, but the thallus of the present (in the larger specimens a little exceeding an inch in the largest diameter) is foliaceous rather than crustaceous. It is, however, thickish, and easily broken, and the plant appears certainly to be comparable rather with *L. rubina*, than with any known form of *Parmelia conspersa*. The lobes are rolled closely together in all the specimens, and none of them show traces of having been gathered *in situ*. A fuller description is reserved, in the hope that other observers may be fortunate enough to detect fertile plants.

LECANORA (Squamaria) FROSTII. *Squamaria*, Tuckerm. Suppl. I., in Amer. Journ. Sci. 25, p. 425. On granitic rocks, from New England to Virginia.

LECANORA SUBFLAVA, sp. nov.: thallo cartilagineo primitus contiguo lævigato rimuloso granulatoque luteo hypothallo atro decussato; apotheciis mediocribus sessilibus disco plano-convexo fulvescente margine thallo subconcolore obtuso integro. Sp. in thecis clavatis incolores, submediocres, ovoideo-ellipsoideæ, simplices, diam. $1\frac{1}{2}$ - 2° rarius $2\frac{1}{2}^{\circ}$ longiores. Trunks in the island of Cuba, *Mr. Wright* (Lich. Cub. n. 167). Related, in habit and in the spores, rather to *L. subfusca* than *L. varia*.

LECANORA PINGUIS, sp. nov.: thallo crasso areolato-plicato sordide olivaceo-virescente intus pallido-sulphureo, hypothallo infuscato; apotheciis majusculis adnatis disco mox turgido lutescenti-carneo subtiliter pruinoso, margine thallino tenui subcrenulato demum excluso. Sporæ in thecis clavatis octonæ, incolores, ex ellipsoideo plus minus oblongæ, simplices, limbatae, sporobl. dein variabili, diam. 3–4° longiores. On metamorphic sandstone rocks, at 2,000 feet, in Oakland county, California, *Mr. Bolander*. Thallus tartareous, often two lines in diameter, and the thickest specimens, made up apparently of several successive layers, reaching half an inch through, contiguous, the surface cracked into irregular, coarse, convex areoles, which are often plaited, and become sometimes effigurate at the circumference, and in young fronds, dull olivaceous-green without, and pale sulphur-colored within, the hypothallus being indicated by a purplish-brown discoloration. Apothecia from half a line exceeding at length a line and a half in diameter, from innate becoming superficial, and the pale-yellowish, at length a little flesh-colored, obscurely powdery disk (which is pale within) turgid, (much in the manner of conditions of *L. varia*, v. *polytropa*), when the thinnish, scarcely prominent, irregularly wrinkled or notched margin is sometimes excluded. Spores irregularly oblong-ellipsoid, and oblong. Spermatogones scarcely a little prominent, with fuscous ostioles; the spermatia needle-shaped and bowed. There is some appearance in this lichen of a tendency toward the effigurate type of thallus, but it is not marked, and there is nothing else to distinguish the plant from *Lecanora* proper, where it is associable with the group represented by *L. varia*.

URCEOLARIA CHLOROLEUCA, sp. nov.: thallo tartareo rugoso e glaucescente flavido intus pallide sulphureo hypothallo albo; apotheciis ex urceolato margine proprio denticulato-fisso reflexo mox explanatis, disco convexulo nigro cinereo-subpruinoso margine thallino integro evanescente. Sp. 8næ, ovoideo-ellipsoideæ, mox fuscæ, 4–8-blastæ sporobl. irregulariter subdivisis, diam. 2–2½° rarius 3° longiores. On the earth ("Cuchillas de Baracoa") in the island of Cuba, *Mr. Wright* (Lich. Cub. n. 123). A distinct form (whatever its rank may prove to be), contrasting sharply with the elegant specimens of *U. cinereo-caesia*, (Sw.) Ach., of Lindig's New Granada collection (n. 2,503), but not quite so diverse from those of Wright's Lich. Cub. n. 161. The spores of this last are perhaps longer, but in other respects like those of both the others, as also of *U. scruposa* (Fr. Lich. Suec. n.

282); and Nylander (Prodr. Fl. N. Gran. *in loco*) refers the West Indian lichen of Swartz (*U. cinereo-cæsia*) to the European; which, especially in the var. *gypsacea* (Welwitsch Cr. Lusit. n. 97, 100, saltem pr. p.), often resembles it.

THELOTREMA LATILABRUM, sp. nov.: thallo crassiusculo lævigato inæquabili dein ruguloso e glauco olivaceo-subfuscescente; apotheciis majusculis innato-prominulis ex urceolato-scutelliformi dein dilatatis difformibus, excipulo exteriori margine lato acuto stellato-fisso reflexo albo-pulverulento discum planum nigrescentem velo subcrustaceo multifore demum rupto coopertum cingente. Sp. in thecis cylindraceo-clavatis octonæ, incolores, oblongæ apice altera nunc attenuatæ, 6-8-blastæ, diam. 3-6° longiores. Paraphyses filiformes. On trunks in the island of Cuba, *Mr. Wright* (Lich. Cub. n. 137). The spores connect this fine *Thelotrema* with *T. olivaceum*, Mont., but externally it is far more like *T. Auberianum* of the same author. Apothecia a line in diameter, but the largest reaching two lines; the exterior (proper) exciple brown within, where it is white-powdery, and concrete with the thallus without; the interior exciple deficient. As in *T. Auberianum*, the now only slightly recurved white margin of the exciple remains sometimes persistently entire, being either elevated and obtusish, or, again, scarcely exceeding the thallus; but more frequently perhaps it is deeply cleft into four or five acute, at length reflexed lobes, a state characterizing the larger apothecia, while also observable in others from the first.

THELOTREMA LEUCASTRUM, sp. nov.: thallo cartilagineo tenui lævigato pallide olivaceo-fuscescente hypothallo fusco-nigro; apotheciis majusculis innatis scutelliformibus dilatatis, excipulo exteriori reflexo stellato-fisso albo-pulverulento discum planum tenuem superne nigricantem albo-pruinose cingente, interno deficiente. Sp. in thecis subcylindraceis uniserialiter octonæ, parvulæ, pallide fuscescentes, e cocceiformi-ellipsoideo dein magis oblongæ apicibus obtusis, 3-4-blastæ, diam. 2-3° longiores. Paraphyses filiformes distinctæ. Trunks in the island of Cuba, *Mr. Wright* (Lich. Cub. n. 158).

Var. β *difforme*: apotheciis minusculis confluentibus elongatis aliterque difformibus margine pulveraceo sub-dissoluto. With the last. (*Wright* Lich. Cub. n. 159.) The species will be most readily compared with *T. platycarpum*, described in a previous part of these Observations, but the interior exciple, which is so distinct and elegant

in that species, is wholly wanting in this. The spores, though not dissimilar, generally, to those of *T. platycarpum*, are somewhat larger, and the outline is constantly a little different. It will not be easy to find any subdivision of the present genus on the presence or absence of the interior exciple.

THELOTREMA PLATYCARPOIDES, sp. nov.: thallo cartilagineo tenui æquabili dein ruguloso pallide viridi-fuscescente; apotheciis mediocribus innato-prominulis urceolato-scutelliformibus apertura ampla, margine exteriori elevato subintegro dein reflexo discum planum tenuem superne nigricantem albo-pruinose excipulo interno membranaceo albido connivente instructum cingente. Sp. octonæ, pallide fuscescentes, ex ellipsoideo apicibus acutis dein subelongatæ apice altera attenuatæ, 6-blastæ, diam. $3\frac{1}{2}$ – $4\frac{1}{2}$ ° longiores. Paraphyses filiformes conglutinatæ. Trunks in the island of Cuba, *Mr. Wright* (Lich. Cub. n. 157). Differs from *T. platycarpum* in its 6- (rarely 8-) locular, larger spores, as well as in its smaller, urceolate apothecia, in which the outer margin is more commonly erectish and nearly entire. But the latter feature is not to be relied upon (as already suggested under *T. latilabrum*), and the lichen occurs in states resembling *T. platycarpum* much as the variety of the last-described species does its type, except that here the distinction of the spores continues.

THELOTREMA LIRELLIFORME, sp. nov.: thallo crassiusculo tenuissime ruguloso-granulato lævigato dein tartareo-subfarinoso e glaucoviridulo cinerascete hypothallo fusco-nigro; apotheciis majusculis innatis lirellato-diformibus, excipulo exteriori prominulo margine crasso subintegro discum nigrum velamine albo coopertum cingente. Sp. octonæ, oblongo-ellipsoideæ, tetrablastæ sporobl. integris, dein nigrofuscae, diam. 2– $2\frac{1}{2}$ ° longiores. Trunks in the island of Cuba, *Mr. Wright* (Lich. Cub. n. 150). Belongs to the same group with the variable *T. Auberianum*, Mont., and *T. Cubanum* of the present writer, but is rather remarkably distinguished by its much-elongated apothecia, sometimes nearly three lines long, and its blackish spores. The lirelliform exciple, which not unfrequently suggests that of some *Graphis*, not remote from *G. vernicosa*, Fée (Nyl. in Herb. Lindig. n. 751, 898) splits sometimes irregularly, becoming 3–4-radiate, recalling short-branched apothecia of the cited *Graphis*, and still more those of specimens of *G. Lyellii* (Sm.) Ach.

THELOTREMA CATASTICTUM, sp. nov.: thallo subtartareo inæqua-

bili dein subtiliter pulveraceo glaucescente; apotheciis minutis immersis urceolatis thallo submarginatis apertura ampla, excipulo laxo margine incurvo discum conoideum nigrescentem cingente. Sp. in thecis elongatis subcylindræis octonæ, pallide fuscæ, lato-oblongo-ellipsoideæ, 6-8-blastæ sporobl. lentiformibus integris, diam. 2-3° longiores. Paraphyses filiformes conglutinatæ. On trunks in the island of Cuba, *Mr. Wright*. *T. compunctum* (Sm.) Nyl. (Herb. Lindig. n. 2,885) has not very dissimilar though smaller apothecia, but differs from the present in its muriform-pleioblastish, larger spores, as well as in general habit.

THELOTREMA SIMPLEX, sp. nov.: thallo crassiusculo rugoso-verrucoso lævigato pallide cinerascete; apotheciis confertis valde minutis thalli verrucis submarginantibus immersis, excipulo subgloboso pallido basi continuo superne nudo radiatim substriatulo poroideo-pertuso discum nucleiformem livescentem fovente. Sp. octonæ, mox fusæ, ellipsoideæ, 4-8-blastæ sporobl. dein muriformi-partitis, diam. 1½-3° longiores. Paraphyses conglutinatæ. Trunks in the island of Cuba, *Mr. Wright* (Lich. Cub. n. 154). Belongs to the neighborhood of *T. Wightii*, (Tayl.) Nyl., and is especially comparable with *T. trypanoides*, Nyl. (Wright. Lich. Cub. n. 156), but differs in the conspicuous denudation of the upper portion of the verrucarioid apothecium, and apparently in the spores. The proper (exterior) exciple of *Thelotrema*, for the most part so conspicuously conditioned by the thallus, has in the present lichen (as also in *T. album* (Fée), and others of that group) only an accidental relation to it. There can hardly be any doubt that the simple receptacle of *T. simplex* corresponds to the *exterior* exciple of species with compound receptacles (as compare the not dissimilar *T. sphinctrinellum*, Nyl. in Herb. Lindig. n. 2808): but when, as in *T. compunctum*, the exciple soon separates from the thallus, falling loosely inwards, it is difficult not to take it for the *interior*, and the rim of thallus, often a little prominent, which surrounds it, as in fact as well as appearance the exterior.

GYALECTA CARNEO-LUTEOLA, sp. nov.: thallo tenuissimo albo; apotheciis minutis innato-erumpentibus disco concavo-plano luteolorubello margine subconcolori subintegro, velo thallino dentato-lacero disparente. Sp. in thecis elongato-clavatis octonæ, incolores, sub-dactyloideæ, sæpius diblastæ, diam. 3-5° longiores. Paraphyses filiformes capitulatæ. On trees in the island of Cuba, *Mr. Wright*. As in *G.*

carneo-lutea (Turn.) the innate disk is enclosed by a thin, thalline veil or exciple, which bursts as the mature apothecium emerges, and finally for the most part disappears. The lichen differs from the European, in being only one third of the size, in its higher-colored apothecia, and smaller, bilocular spores, passing only irregularly into 3-4-locular conditions. The spores of *G. carneo-lutea* are commonly quadri-locular, but pass irregularly and imperfectly into 5-6-locular states. The thalline veil is by no means peculiar to these species, being sufficiently obvious in *G. foveolaris* and *G. geicola*, as indicated by Th. Fries, and assuming the character of a genuine thalline exciple in *G. rubra*; and it is taken, and with reason as it appears to me, into his definition of the genus, by Dr. Fries (Lich. Arct. p. 137; Gen. Het. p. 73.)

LECIDEA (*Biatora*) PARVIFOLIA, Pers.: thallo squamuloso-micropyllo e viridi-glauescente fuscescente squamulis subcartilagineis imbricatis crenato-incisis laciniatisve hypothallo demum fusco-nigro; apotheciis plano-convexis mox prolifero-diformibus, margine obtuso tenuescente dein evanido, varie fuscescentibus rufo-fuscis denigratisque. Sp. in thecis clavatis sub-octonæ, incolores, simplices, ex ellipsoideo oblongæ, diam. e 2° dein 4-6° rarius 8° longiores. *Lecidea parvifolia*, Pers. in Gaudich. Bot. Uran. p. 192. *Biatora*, Mont. Prodr. Fl. Fernand. *Parmelia* (*Psoroma*), Mont. Pl. Cell. Cub. p. 214, t. 10, f. 3. The lichen appears to be common throughout the tropical regions of the earth, and reaches northward in America as far as the low country of Carolina. It is variable in the development and differentiation of the thallus and hypothallus, in the colors, and in the dimensions of the spores. The forms which follow are those collected in Cuba by Mr. Wright; and after a good deal of labor, lately repeated, I find it impossible to separate any of them from the type indicated by Persoon. Specimens of several of these were sent, before publication, to Dr. Nylander, in Paris, and this eminent lichenographer has since published his own determinations of the same, which will be cited below.

a. Sporæ majores magis elongatæ. (Wright. Lich. Cub. n. 179.) *L. longiuscula*, Nyl. in Prodr. Fl. N. Granat. in Ann. Sci. Nat. The larger specimen is remarkable, in the younger portions, for its white hypothallus; the squamules are also much divided, and the apothecia (not appressed as is more common in other conditions, especially where the thallus is less developed, but sessile on the ascending lobes) are especially perfect and well-bordered. The smaller specimen is a sub-

granulose condition (rather comparable, as respects the thallus, with Lich. Cub. n. 183, to be noticed under *b*, and also with Lich. Cub. n. 185), with a blackish-brown hypothallus, but apothecia and spores not unlike those of the other. In Lich. Cub. n. 179, the squamules are now white-pubescent beneath (a feature finally disappearing, with the hypothallus, in this form), and the same development is observable in n. 180, and also in n. 186, which last I take to be *L. parvifolia*, as limited by Nylander (l. c.), who brings this feature into his description.* Like everything else, the hypothecium also varies in these forms from pale to dark-brown.

b. Sporæ minores sæpius ellipsoideæ. (Wright. Lich. Cub. n. 181.) *L. breviuscula*, Nyl. l. c. The thicker, larger, crenate squamules of this form are more appressed, with something of an effigurate aspect, and are often bordered by the conspicuous, lurid-brown, here fibrillose hypothallus; while the thallus itself becomes at length more or less brownish. But there is nothing here to separate the lichen from states of *a*; and the ellipsoid spores become finally oblong. From this, the lichen in Lich. Cub. n. 183 (*L. intermediella*, Nyl. l. c.) appears to me to differ much as the subgranulose state of n. 179, from the squamulose one. The hypothecium varies in these forms, as in *a*.

c. Sporæ adhuc minores. (Wright. Lich. Cub. n. 182.) *L. parvifoliella*, Nyl. l. c. Thallus from greenish becoming pale yellowish and at length brownish, the crenate scales passing into narrowly lobed ones, the hypothallus and the apothecia (which are at first brown) finally black, and the hypothecium blackish-brown. Spores of the species, but smaller than in the other forms.

d. corallina: squamulis corallinis. (Wright. Lich. Cub. n. 184.)

e. subgranulosa: thallo diminuto squamaceo-granuloso. (Wright. Lich. Cub. n. 185.) Such appears to me to be the range of variation of this species, so far as exhibited in the rich collections of Mr. Wright. It is no more perhaps than were fairly to be presumed in a widely-spread, squamulose lichen, developed by tropical moisture and heat. Much as some of these forms diverge from others in the thallus and apothecia, these differences do not appear to afford satisfactory grounds

* *Biatora Fendleri*, Mont. & Tuck. in Ann. Sci. ser. 4, 8, p. 296, from Venezuela, is an elegant expression of this pubescent form, comparable with Lich. Cub. n. 186, and also with n. 181 of the same collection.

for specific distinction.* And, if I am not so far mistaken, the spores, in which a certain degree of variableness in dimensions is also presumable, seem hardly sufficient alone.

LECIDEA (*Biatora*) *ONCODES*, sp. nov.: thallo granulis minutis dein subconfluentibus rimoso viridi-cinerascente hypothhallo fuscescente evanido; apotheciis mediocribus appressis, disco mox convexo rufo-fusco hypothecio nigricante imposito margine tenui pallidiori flexuoso, prolifero-difformibusve majusculis in soredia farinacea sæpe fatiscentibus. Sp. octonæ, parvæ, incolores, simplices, oblongæ, diam. 4–6° longiores. Paraphyses conglutinatæ. On trunks in the mountains of Cuba, *Mr. Wright*. (Lich. Cub. n. 187.) Remarkable for the frequent transformation of the apothecia into soredia.

LECIDEA (*Biatora*) *ORPHNÆA*, sp. nov.: thallo e granulis minutis dein coalescentibus subimbricatis rufo-fusciscentibus hypothhallo tenui fusciscenti-pallido; apotheciis minutis sessilibus disco plano-convexo nigro-fusco intus nigricante margine obscuriore evanido demum proliferis. Sp. in thecis clavatis 10–15-sporis, parvæ, incolores, oblongæ, diam. 2½–5° longiores. Paraphyses mox distinctæ. On trunks in the island of Cuba, *Mr. Wright*. Comparable with *L. furfuracea*, Pers., Nyl. (Lindig. n. 840), but apparently quite distinct.

LECIDEA (*Biatora*) *FURFUROSA*, sp. nov.: thallo granuloso e pallido-fusco-cinerascente hypothhallo dein nigro; apotheciis mediocribus sessilibus disco plano pallido-fusculo hypothecio nigro-fusco imposito margine tenui nigricante. Sp. octonæ, mediocres, incolores, simplices, ovoideæ, dein oblongo-ovoidæ apice altera nunc attenuatæ, vel fusiformi-ellipsoideæ, diam. 1½–3° longiores. Paraphyses conglutinatæ. Perhaps nearest to *L. Piperis*, (Spreng.) Nyl., which has a different thallus, and rather smaller spores.

LECIDEA (*Biatora*) *POLYCAMPIA*, sp. nov.: thallo subcartilagineo inæquabili rimoso mox sorediifero ex olivaceo cinerascente; apotheciis majusculis adnatis disco subplano opaco lurido-rufescente hypothecio crasso nigro imposito margine crasso obtuso pallidiori mox flexuoso. Sp. in thecis clavatis 6–8næ, incolores, simplices, ex ovoideo ellipsoideæ, nitidæ, diam. 1½–2° longiores. On trunks in the island of

* *Lecidea Halei* (Tuck.) Nyl. Enum. Suppl. (*Pannaria*, Tuck. Suppl. 1, l. c. p. 424), though differing from the other forms above considered, and in itself sufficiently distinct-looking, is, in the larger view we have been enabled here to take, by no means more separable than those.

Cuba, *Mr. Wright* (Lich. Cub. n. 194). It is impossible not to distinguish this lichen from *L. aurigera*, Fée (Lich. Cub. n. 193); but both may prove to be conditions of a single type. The granulate thallus of *L. aurigera* is (at least originally, or often) pale-sulphur-colored within, and the narrower margin of the thinner and darker apothecia is at length subcrenulate. *L. hypomela*, Nyl. (Lich. Exot. in Ann. Sci. Nat. 4, 11, p. 223) also occurring in Cuba, is another sufficiently distinct-looking member of the same group, with a thin, and, as compared with the others, depauperate thallus, and still darker, entire apothecia. The spores vary in dimensions in all three, and scarcely afford distinguishing characters.

LECIDEA (*Biatora*) CHLORORPHNIA, sp. nov.: thallo granuloso-farinoso ochroleuco; apotheciis valde minutis innatis planis rufo-fuscescentibus margine tenui evanido. Sp. in thecis clavatis 6-8næ, incolores, simplices, ellipsoideæ dein oblongo-ellipsoideæ, limbatae, diam. $2\frac{1}{2}$ - 3° longiores. Paraphyses distinctæ. On Ficus, Hong Kong, China (U. S. N. Pacif. Expl. Exp.), *Mr. Wright*. Very like a minute form of *L. querneæ*, (Dicks.) Ach. The European lichen is pronounced immarginate by several recent writers, but an obtusish, paler, flexuous excipular margin (contrasting with that of the present) is certainly evident in Nyl. Lich. Par. n. 134, and also in an equally fine specimen from Borrer. The spores of *Mr. Wright's* plant are always colorless, while those of *L. querneæ* (passing from subglobose into ovoid-ellipsoid) are at length, in all my specimens, brown, as indicated by Dr. Koerber (Syst. p. 209), who distinguishes the lichen from *Biatora* by this certainly remarkable character. The hypothallus of *L. querneæ* is originally whitish, according to Koerber, l. c., but it certainly appears to blacken (as indicated by Fries) in a specimen from Portugal (Welwitsch. Cr. Lus. n. 53) before me, which is both bordered and decussated by black lines.

LECIDEA (*Biatorella*) WRIGHTII, sp. nov.: thallo e granulis sub-tartareis globularibus conglomeratis glaucescentibus cum hypothallo confusis; apotheciis mediocribus adnatis e fusco nigricantibus disco subplano primitus cinereo-pruinoso hypothecio fusco-nigro imposito marginem obtusum integrum demum subexcludente. Sp. in thecis elongatis oblongis myriosporis minutissimæ, globulosæ, incolores. Paraphyses filiformes distinctæ. On the earth, growing upon mosses, in the eastern parts of the island of Cuba, *Mr. Wright* (Lich. Cub. n. 235).

Granules of the crust now vermilion-colored within, as in a not wholly dissimilar granulate condition of *L. parasema*. More rarely the exciple is colored like the thallus. There is a similarly whitish-margined state of *L. (Biatorella) conspersa*, Fée (Wright. Lich. Cub. n. 224). The lichen is dedicated to my excellent friend the discoverer, to whose ardor and acuteness, displayed in every quarter of the globe, Botany, and especially the knowledge of Lichens, has been indebted, as to few others.

LECIDEA (Bilimbia) LUTEO-RUFULA, sp. nov.: thallo cartilagineo contiguo lævigato rimuloso viridi-glaucescente hypothallo albo submarginato; apotheciis mediocribus appressis planis dein flexuoso-lobatis disco e luteolo-rufescente demum fulvo marginem tenuem integerrimum pallidiorem subæquante. Sp. in thecis clavatis suboctonæ, parvæ, incolores, simplices, ex ovoideo-fusiformi-ellipsoideæ, diam. $2\frac{1}{2}$ – 5° longiores. Paraphyses conglutinatæ. On trunks, Loo Choo Islands (U. S. N. Pacif. Expl. Exp.), *Mr. Wright*. Hypothecium pale. Apothecia flatter and with a thinner margin than in the tropical lichens, known to me, nearest related to *L. vernalis*, as *L. lætior*, Nyl. (Wright. Lich. Cub. n. 197), and much more comparable, except in color, with *L. russula*. Like the lichen of Cuba first cited, as well as *L. subvernalis*, Nyl. (Lich. Cub. n. 198), the present also differs from the Northern plant (Fr. Lich. Suec. n. 224, Stenh. Suec. n. 54, a) in its smaller spores, which in *L. luteo-rufula* are always simple. As respects the size of the spores, *L. cinereo-rufescens*, Nyl. (Wright. Lich. Cub. n. 199) agrees better with *L. vernalis*, but differs in other respects from that, and especially from the present. I venture to refer this to *Bilimbia* in order to keep it in its natural relations to *L. vernalis*, which it is unnatural to place in a distinct group from *L. sphaeroides*, the two latter species scarcely indeed differing in most respects, except that the simple spores of the first pass only into the bilocular state, while in the last the differentiation is carried further, to quadrilocular.

LECIDEA (Bilimbia) PELLÆA, sp. nov.: thallo tenuissime leproso viridi-cinerascente hypothallo nigro; apotheciis parvis adnatis margine tenui ruguloso fusco-nigro discum planum opacum livido-nigricantem intus nigrum cingente. Sp. octonæ, parvæ, incolores, ex oblongo subbacillares, sæpius diblastæ, dein tetrablastæ, diam. 4 – 6° longiores. On trunks in the mountains of Cuba, *Mr. Wright* (Lich. Cub. n. 206).

LECIDEA (Bilimbia) SCITULA, sp. nov.: thallo tenui contiguo in-

æquabili glauco-viridulo cum hypothallo confuso; apotheciis minutis appressis disco mox convexo carneo-rubello margine tenuissimo demisso integro albido. Sp. 8næ, incolores, dactyloideæ, 5-8- sæpius 8-blastæ, diam. 4-6° longiores. On trees in the eastern part of the island of Cuba, *Mr. Wright* (Lich. Cub. n. 202). Hypothecium brownish. Apothecia rather larger than those of *L. orphnæa*. One of a little group of closely allied lichens, of which the species next to be described, and also, if I mistake not, *Biatora pusilla*, Mont. Cuba, p. 199, t. 10, f. 2, "apoth. minimis carneo-luteolis excipulo granulato margine dentato-crenato," and quadrilocular spores, are other members.

LECIDEA (Bilimbia) PALMICOLA, sp. nov.: thallo tenuissimo contiguo æquabili stramineo-glauescente cum hypothallo confuso; apotheciis minutis sessilibus, disco subplano luteo fulvescente margine integerrimo concolore evanido, accessorio albo primitus subcinctis. Sp. in thecis clavatis octonæ, incolores, dactyloideæ, tetrablastæ, sæpe obliquæ vel curvulæ, diam. 2-3° longiores. On leaves of palms, in the island of Cuba, *Mr. Wright* (Lich. Cub. n. 201). The colors make this little lichen easily distinguishable. The adnate apothecia become finally free at the circumference, and are rarely at length proliferous. The marginate disk rests upon, or is sometimes elevated by, a white layer, which often more or less borders it.

LECIDEA (Bilimbia) THYSANOTA, sp. nov.: thallo subtartareo leproso-granuloso dein granulis confluentibus rimoso albo hypothallo fibrilloso concolore fimbriato; apotheciis parvis sessilibus, disco plano e rufo-fusco nigrescente margine demisso pallidiore evanido instructo, strato albo subelevatis marginatisque. Sp. in thecis clavatis confertis octonæ, parvæ, incolores, ex ellipsoideo subdactyloideæ et oblongæ, 2-4-blastæ, diam. 2½-4° longiores. Trunks in the mountains of Cuba, *Mr. Wright* (Lich. Cub. n. 210). The extreme edge of the hypothalline fringe is finally darkened. Paraphyses scarcely to be distinguished. Hypothecium fuscescens. Compared by Dr. Nylander (l. c.) with his *L. byssomorpha*, occurring, "sub. n. 811 admixta," in the N. Granada collection of Lindig, and distinguished by its byssoid thallus, "verging towards the *Byssocaula*." The lichens of Mr. Lindig's collection were not put up by the eminent lichenographer who has so ably illustrated them, and there is here and there some confusion of specimens. In my copy of the collection, there is, mixed with *L. vigilans*, under No. 811, a not wholly dissimilar *Bilimbia* (th. granu-

loso albido hypothallo tenui fuscescente ; apoth. mediocribus sessilibus lecanoroideis margine obtusiusculo mox demisso albido discum subplanum nigro-fuscum hypothecio concolore impositum cingente : sp. in th. elongato-clavatis octonis mediocribus incoloribus e dactyloideo fusiformibus 4 - 6- plerumque 6-blastis, diam. 3 - 5° sæpius 5° longioribus), which, with a thallus not unlike that of *L. thysanota*, a feature separating it from *L. byssomorpha*, Nyl., combines apothecia differing from those of both, and spores of almost twice the dimensions, and may, not inappropriately (with reference to the small size of the fruit in most of the species of this group), be called *L. majorina*.

LECIDEA (Bilimbia) LEUCOCHEILA, sp. nov.: thallo tenui cartilagineo mox contiguo inæquabili cinerascante ; apotheciis mediocribus adnatis, disco plano-convexo fusco-nigro hypothecio fusco imposito margine integerrimo albido-livescente, demum proliferis. Sp. in thecis clavatis octonæ, parvæ, incolores, dactyloideæ vel subfusiformes, tetrablastæ, diam. 2½ - 3° longiores. Paraphyses distinctæ filiformes. On dead wood in the island of Cuba, *Mr. Wright* (Lich. Cub. n. 208). Comparable with *L. triseptata*, Hepp, but quite distinct from that species. The apothecia are a little smaller than those of *L. majorina*, and differ very considerably otherwise, but there is some observable resemblance in the colors.

LECIDEA (Bacidia) MICROPHYLLINA, sp. nov.: thallo squamuloso-microphylo viridi-cinerascante (fuscescente aut dealbato) squamulis cartilagineo-membranaceis imbricatis crenato-incisis laciniatisve hypothallo tenui disparente ; apotheciis plano-convexis e luteolo-pallido rufescentibus (rubellis aut denigratis) margine obtuso tenuescente dein evanido, demum flexuoso-lobatis proliferisque. Sp. in thecis clavatis octonæ, incolores, aciculares, graciles, diam. 15 - 30° longiores. On trunks in the island of Cuba, *Mr. Wright*.

a. Squamulæ magis appressæ crenatæ sporis longioribus. (Wright. Lich. Cub. n. 211.) *L. microphyllina*, Nyl. l. c.

b. Squamulæ adscendentes laciniatæ sporis brevioribus. (Wright. Lich. Cub. n. 212.) *L. tryptophyllina*, Nyl. l. c.

c. Squamulæ laciniatæ mox dealbatæ dein, deliquescentes soorediatæ sporis diminutis. (Wright. Lich. Cub. n. 213.) *L. leucophyllina*, Nyl. l. c.

Var. β *subgranulosa*: thallo diminuto granulis squamaceis in crustam inæquabilem demum conglobatis. (Wright. Lich. Cub. n. 214 - 218.) *L. cognata*, & *L. pertexta*, Nyl. l. c.

A tropical *potentiation* of *L. rubella*, (Ehrh.) Schaer. (considered as representing the group of which it is a member), analogous to and sometimes not at once distinguishable from *L. parvifolia*, which I take for a similar higher expression of *L. vernalis*. The latter (*L. parvifolia*) appears the stronger species, and is represented by a larger suite of forms, externally, at least, not so well separable from each other, while the lichens approaching it, yet more closely akin to *L. vernalis* (*LL. subvernalis*, *latior*, *cinereo-lutescens*, *luteo-rufula*, &c.), are also more varied and distinguishable from the Northern plant than the corresponding tropical conditions associable with *L. rubella*. Strikingly characterized, at their centres, as both species are, in the crustaceous sub-genera to which they belong, by their squamulose habit, this distinction disappears at the extremes, in granulose or scurfy forms not always separable by the eye from Northern members of their groups. Of the enumerated forms which make up *a* (as the lichen is represented in Mr. Wright's collection), *a* appears, so far as all the evidence from external characters goes, to pass directly into *b*; of which *c* is (as I understand it) no more than an abnormally whitened, finally deliquescent condition; and in this case, I take it, the evidence of diversity derivable from the difference of dimensions in the spores must be subordinated. The variety β is the granulose condition of the lichen, analogous to the similar state of *L. parvifolia*, and often very like it; but the former is perhaps more readily distinguishable from its type, or in other words less easily reducible to it, than the latter. The apothecia of *L. microphyllina* are originally not unlike those of *L. rubella*, and vary from pale-lutescent to rufous and reddish, at length blackening; and the hypothecium passes, in the same way (as in *L. rubella*, taken in its largest sense, or as expressed in Nyl. Prodr. Lich. Gall. p. 114, and Enum. Gen. Lich. p. 122), from almost colorless to brownish, vinous, and black. The spores, slender in all the forms, are especially diminished in *c*, but Mr. Wright collected another lichen, with a thallus scarcely distinguishable from that of *c*, in which they are more elongated than in any of the conditions here described,* thus approaching the filiform and still more elongated spores of *L. prasina*, Mont. & Tuck., a lichen externally most resembling Lich. Cub. n. 218.

* In all the larger specimens of my copy of Stenh. Lich. Succ. n. 53 (the lichen is *Bacidia rubella*, v. *fallax*, Koerb. Par. p. 131, and has been separated as a species by Lönnroth), I find the spores remarkably elongated.

It remains only to add, that specimens of most of the forms of the species, as distinguished here, being sent (before publication) to Dr. Nylander, that eminent lichenist has published his own determination of the same (in the place already cited under *L. parvifolia*), which should be compared with the above.

LECIDEA (Bacidia) MEDIALIS, sp. nov.: thallo granulis cartilagineis mox applanatis confluentibus diffracto-rimoso cinerascete cum hypothallo pallido confuso; apotheciis parvis plano-convexis e luteolo-pallido rufescentibus margine obtuso dein evanescente. Sp. in thecis clavatis suboctonæ, incolores, e dactyloideo-fusiforimi bacillares, sæpius tetrablastæ, diam. 5 - 10° longiores. Paraphyses mox distinctæ. Trunks. In Nicaragua (U. S. N. Pacif. Expl. Exp.) *Mr. Wright*, who also collected it in Cuba (Lich. Cub. n. 203). Properly a *Bilimbia*, but the distinction between this group and *Bacidia* disappears in the lichen, which thus curiously illustrates Fries's reduction of the European types of both groups to a single species. I am at any rate unable clearly to distinguish the *Bilimbia* in Lich. Cub. n. 204, with dactyloid, quadricocular spores, very like those of *L. sphaeroides* (Stenh. Lich. Suec. n. 54, b), but smaller,* and finally a little elongated, from the above-described specimens; which yet may otherwise easily be taken (though differing apparently in the color of the thallus, and the smallness of the apothecia, and diverging considerably in the spores) for a tropical variety of *L. (Bacidia) rubella*.

LECIDEA (Bombyliospora) LEPTOCHEILA, sp. nov.: thallo tenui rugoso-verruculoso ex albido dein fuscescete hypothallo fibrilloso nigricante sublimitato; apotheciis mediocribus adnatis plano-convexis disco fusco-nigro opaco marginem tenuem integerrimum concolorem mox excludente. Sp. octonæ, sub-parvæ, incolores, oblongo-ellipsoideæ, diblastæ, dein obliquæ, diam. 2 - 3½° longiores. Paraphyses conglutinæ. On trunks in the island of Cuba, *Mr. Wright* (Lich. Cub. n. 227). Distinct from *L. endochroma* (Fée), Nyl. (Wright Lich. Cub. n. 226), in its differently colored thallus, now elegantly fringed by the fibrillose hypothallus, thinner-margined apothecia, which are constantly white and not yellow within, and in its smaller spores. It seems impossible to deny the near affinity of these two species to *L. Taitensis*

* Not larger, as, *lapsu calami*, they are said to be in the ticket of the cited specimen. The spores differ, therefore, from those of the Northern lichen just as the spores of *L. letior* and *L. subvernalis* from those of *L. vernalis*.

(Mont.) and *L. vigilans* (Tayl.), or that the latter belong to the same natural group with *L. tuberculosa*, Fée; and, in that case, the group cannot well be limited by the number of the sporoblasts, any more than *Bilimbia*. But the spores of *L. endochroma*, and of the species described above, are remarkable (as compared with other *Bombyliosporæ*) for their smallness, and are comparable rather with those of *L. atropurpurea* (Massal.), which is *L. intermixta*, Nyl. This is not always unlike small states of *L. tuberculosa*, &c., and I have seen similar states of *L. vigilans* referred to its neighborhood at least (under the name of "*L. carneola*," in which was understood possibly the rather unfortunate var. *arceutina*, Ach.) in European collections.

LECIDEA (Bombyliospora) PACHYCHEILA, sp. nov.: thallo contiguo inæquabili mox verrucoso glaucescente hypothallo demum nigro sublimitato; apotheciis mediocribus adnatis disco subplano rufo-nigricante margine tumido obtuso albido persistente. Sp. 2-4næ in thecis oblongis, magnæ, oblongo-ellipsoideæ, 4-8-blastæ, sæpius curvulæ, diam. 3-5° longiores. Trunks. South Carolina, *Mr. Ravenel*. Mississippi, *Dr. Veitch*. Alabama, *Mr. Beaumont*. Island of Cuba, *Mr. Wright*. (Lich. Cub. n. 230.) Distinguished from *L. pachycarpa* and *tuberculosa* by its shorter, curved (now lunate, and now S-shaped) spores, which occur in twos, threes, and fours, in the sporesacks; as well as by its thick, white exciple, which is often tumid, when there is some appearance of an accessory or false margin.

LECIDEA (Bombyliospora) AUREOLA, sp. nov.: thallo cartilagineo contiguo tenui rimoso flavido hypothallo tenui nigricante; apotheciis parvis sessilibus disco plano-convexo opaco fulvo-aurantiaco hypothecio pallido imposito marginem tenuem integerrimum concolorem subæquante. Sp. 6-8næ in thecis clavatis, incolores, dactyloideæ vel subfusiformes, 5-6-blastæ, sporobl. rotundatis, diam. 4-6° longiores. Paraphyses mox distinctæ. Trunks, in the island of Cuba, *Mr. Wright*. Comparable with *L. Domingensis* (Pers.), Nyl. (Wright Lich. Cub. n. 231), but receding still further from the type of *Bombyliospora*.

LECIDEA (Heterothecium) VULPINA, sp. nov.: thallo tenui subcartilagineo contiguo inæquabili dein rugoso-verruculoso e glaucescente aurantiaco-flavido hypothallo tenui nigricante; apotheciis submediocribus sessilibus margine obtuso integro ex aurantiaco sanguineo-rufo discum planum rufo-nigrescentem subpulverulentum hypothecio pallido impositum superante. Sp. 2-4næ in thecis, mediocres, fere semper

incolores, e cocciformi oblongo-ellipsoideæ, muriformi-pleioblastæ (ser. transv. 6–12, long. in medio 4–5), diam. $1\frac{1}{2}$ –3° longiores. Trunks in the island of Cuba, *Mr. Wright* (Lich. Cub. n. 233). With the thallus of *L. Domingensis*, and similar but smaller apothecia, this lichen presents the muriform spores of *Heterothecium*. In the latter group *L. leucoxantha*, Spreng. (Lich. Cub. n. 234) approaches it nearest, differing in its monosporous sporesacks, and larger, polyblastish (ser. tr. 18–20, long. in med. 8) spores, as well as in thallus, &c. According to Dr. Nylander (l. c.) the *L. leucoxantha*, v. *bispora* of his Enum. Gen. p. 125, relates to this lichen, but neither this name, nor that of *L. bifera*, Nyl. Lich. N. Caled., a plant certainly not remote from ours, is quite appropriate to a species the spores of which occur in twos, threes, and fours, in the sporesacks.

LECIDEA (*Heterothecium*) TURBINATA, sp. nov.: thallo e granulis applanatis in crustam verrucoso-rugulosam dein conglobatis pallido-luteo-fuscescente; apotheciis minutis turbinatis excipulo pallide fusculo basi stipitiformi-constricto margine integro discum e concavo planum rufo-fuscum hypothecio obscuriore impositum demum æquante. Sp. in thecis oblongis singulæ, magnæ, pallide fuscescentes, oblongæ, muriformi-polyblastæ (ser. transv. 30–50, long. 8–10) diam. 5–6° longiores. Paraphyses distinctæ. Encrusting *Coccocarpia parmelioides*, and mosses, in the island of Cuba, *Mr. Wright*. At once distinguishable from other species of *Heterothecium* by its substipitate apothecia, resembling those of *L. pezizoidea*, Ach., upon which Dr. Koerber founds his *Lopadium*. Hypothallus, so far as observed, very thin, and pale. Disk colorless within; resting upon a blackish-brown hypothecium. Paraphyses conglutinate at first, as observed in the related European species by Koerber (Par. p. 175), but soon separating into a loose mass of long, now branched filaments, which are perhaps capitulate, but by no means so distinctly as in the cited Northern lichen (Th. Fr. Lich. arct. p. 201, and herb.). The apothecia of the latter are also less turbinate, this feature being remarkably conspicuous in the tropical species.

LECIDEA (*Buellia*) PARASEMA (Ach.), Fée. *Buellia*, Koerb. Syst. Lich. Germ. p. 228. Notwithstanding some obscurity in the general remarks of Fée, Suppl. p. 101, the descriptions and figures of the spores both of this and of his *L. glaucotheca* (*L. disciformis*, v. *cæsiopruinosa*, Nyl.) appear to me to leave no question that the lichen (with “bilocular

sporidia") which he had in view, as occurring commonly on tropical barks, was the well-known flat state of *L. parasema*, Ach. (*L. disciformis*, Nyl.), which really is common on such barks, and not what is now called *L. enteroleuca*. And this amounts to a determination of *L. parasema* as that part only of the original species which is characterized by bilocular, finally brown spores: a limitation dating at least from 1837, if not from 1824. "*L. disciformis*, Fr.," cited as a synonyme in Moug. & Nestl. Crypt. Vog. n. 745, has no other authority for its definition, that I am aware of, than the specimens published by the French botanists in connection with it, and in my copy at least this definition is uncertain, as one of the three specimens (with a similar hypothallus to that of the other two, only here more evidently conditioning the thin thallus, and smaller, flat, dark-reddish apothecia) has the ovoid, simple spores characterizing *L. enteroleuca*. *L. parasema* being as common as it is in the warmer regions of the earth, and doubtless passing there into states (the varieties *cæcio-pruinosa*, and *æruginascens*, Nyl., and *endococcina* (th. intus miniato), mihi, are some of these) unknown elsewhere, and *L. myriocarpa* (DC.), Nyl., also occurring in those regions, I do not venture at present to distinguish further, by a diagnosis, the *L. catasema* of Lich. Cub. n. 242; but the apparently granulose thallus of this lichen seems to differ from the granulate conditions of *L. parasema*, while the minute, soon proliferous apothecia (the thalamium in which, brownish in a thin section, is made up of conglutinate paraphyses, — contrasting both with *L. parasema* and *L. myriocarpa* the almost colorless thalamium of which consists of loosely coherent, filiform paraphyses), and especially the small spores, which are less than those of the last-named species (Fr. Lich. Suec. n. 353; Nyl. in Lindig. Lich. N. Gran. n. 742) and rather resemble the spores of some *Trachylia*, may well make proper a separate notice of it. There are, in Mr. Wright's collection, some small forms on living bark, approaching the other.

LECANACTIS, Eschw. Syst. p. 14 (founded on *Lichen lynceus*, E. Bot., which Acharius referred first to *Lecidea* and then to *Arthonia*) was accepted by Fries (Lichenogr. p. 374) in a different sense from what it afterwards assumed in the mind of its author, and has been since illustrated and extended by Koerber (Syst. p. 275). The group touches at once on Lecideaceous and Graphidaceous types, and its importance in the system appears tolerably evident if the close natural affinity of *L. lyncea* (an *Opegrapha*, according to Borrer, Schaerer, and

Nylander) to *L. illecebrosa* (which Acharius, Schærer, and Nylander have referred to *Lecidea*) is fully considered; these two species, notwithstanding the divergence in shape of their apothecia, being nearer to each other than to anything else. To these, *L. biformis* (Floerk.), Koerb., for a fine specimen of which I am indebted to Mr. v. Krenpelhuber, approaches near, and *L. abietina* (Ach.), Koerb. chiefly differs in its better-defined, larger apothecia, and rather larger spores. It is with this last that *L. premnea* (*Lecidea premnea*, Ach. Lich. p. 173, 670. Nyl. Prodr. Lich. Gall. p. 138, and Lich. Par. n. 67. Nyl. Lich. Scand. p. 241. *L. abietina* (Sm.), Hook., non Ach. *Opegrapha plocina*, Koerb. Syst. Germ. p. 280. *Pragmopora?* *premnea*, Koerb. Parerg. p. 280), or the little group of which it is the type, is most naturally associable. Long-forgotten and misunderstood, the well-marked European member of this group was published at length, in both the bark and the rock-forms, by Mr. Leighton and Dr. Nylander, and its characters fully indicated in print. But it remained to observe the varying expressions of the type in other, and especially the warmer regions of the earth; and *Lecidea coniochlora*, Mont. & Van den Bosch (Lichenes Javanici, p. 37), scarcely differing from the European lichen (to which it was referred in Nyl. Prodr. Lich. Gall.) except in its longer spores, which are 8-12-locular, while the spores of the European vary mostly from 4 to 6, was the first step, as it is still the most important one, in that direction. *Lecidea insignior*, Nyl. in Prodr. Fl. N. Granat. l. c. (Herb. Lindig. n. 2688) appears to be only a more marked expression of this elongation of the spores, which was also indicated in the earlier *Lecidea premnea*, v. *plurilocularis*, Nyl. Lich. N. Caled. (Ann. Sci. 4. 15, p. 49); a phrase best agreeing, in its present limitation, with the described Java specimens, but not improbably to be extended hereafter to cover the whole extent of the divergence. For there is little else to distinguish these tropical forms. All agree, generally, in their imperfect, or obsolescent thallus, and flattish, black, greenish-pruinose apothecia, the prominent margin of which is peculiarly "wrinkled" (Ach.) or "sub-erose" (Koerb.), with the Northern type, and the blunt-fusiform or "oblong-fusiform" (Nyl.) outline of the spores of the latter is traceable throughout. *Lecidea proximata*, Nyl. in Prodr. Fl. N. Gran. l. c. (the *Lecanactis premnea* of the present writer in Lich. Cub. n. 243, where n. 244 is a form with more elongated spores) is particularly observable for its better-developed thallus and apothecia, the spores being rather intermediate (as is the case also in a

Hong Kong specimen formerly collected by Mr. Wright) between the shorter and longer forms. The large and handsome apothecia of this last condition (*Lecid. proximata*, Nyl.) place it at the head of our specimens, as suggesting even the still more conspicuous and very distinct *Lecanactis Leprieurii* (*Lecidea*, Mont. Guyan. p. 38), which, as is remarked by Dr. Nylander (l. c.), is clearly a member of the present group of species, and perhaps the culmination of it.

We have only left to notice a North American expression of the type of *L. premnea*, diverging from the European in a direction opposite to that which has been considered, and offering, possibly, rather more evidence of distinction. *Lecanactis chloroconia*, Tuckerm. herb., is a rather rare New England lichen, found by me in the White Mountains, growing on rock-maple, and in Hampshire, Massachusetts, on chestnut, and sent to me by my friend Mr. Russell (with dissections indicating its relations to *Lecanactis*), from Vermont (Mr. Frost), which, with a very thin, glaucous-cinerascent, or often almost obsolete thallus, not at all unlike that of conditions of *L. premnea*, and similar but thinner-margined apothecia, combines small, more often exactly dactyloid, quadrilocular spores, not exceeding one third of the size of those of the form *proximata*. As compared with the last, this may well be taken for distinct, but the range of its variations is as yet, perhaps, too imperfectly known.

OPEGRAPHIA MICROCYCLIA. *O. myriocarpa*, Tuckerm. Suppl. I. (Amer. Journ. Sci. 25) p. 429, non Mont. The name originally given to this lichen, occurring in several parts of New England, had been previously applied to a South American species by Montagne. The present has also the advantage of indicating the curious peculiarity of the plant, which is its minute, rounded apothecia.

ARTHONIA (Arthothelium) CYRTODES, sp. nov.: thallo tenui subcartilagineo contiguo inæquabili rimuloso glauco-cinerascente hypothallo nigro sublimitato; apotheciis submediocribus adnatis rotundatis convexis fusco-nigricantibus intus concoloribus. Sp. 8næ in thecis ventricosis, majusculæ, incolores (rarius dein fusciculæ) oblongo-ellipsoideæ, 10-12-blastæ (sporobl. nunc hic illic muriformi-divisis), sæpe curvulæ, diam. 3-5° longiores. Paraphyses obsoletæ. *Lecidea cyrtodes*, Tuckerm. in litt. *Arthonia cyrtodes* & *A. distendens*, Nyl. in Prodr. Fl. N. Gran. l. c.

a. Thallus viridi-glaucescens hypothallo minus distincto, sporis ob-

longo-ellipsoideis, (sporobl. integris,) diam. 3-5° longiores. *Arthonia cyrtodes*, Nyl. l. c. On trunks in the island of Cuba, Mr. Wright (Lich. Cub. n. 245).

β. Thallus dein cinerascens hypothallo nigro, sporis magis oblongis, (sporobl. nunc muriformi-divisis,) diam. 3-4° longiores. *Arthonia distendens*, Nyl. l. c. With the other, in the island of Cuba, Mr. Wright (Lich. Cub. n. 246).

I had referred this to *Lecidea* (in herb., as an aberrant type of the group *Heterothecium*), but the exciple is absolutely deficient, and the lichen belongs, as determined by Dr. Nylander (to whom specimens were sent, in advance of publication, and published by him), to *Arthonia*. I am still, however, unable to discern in the specimens more than the development of a single species. As respects the thallus, the apothecia, and the spore-sacks, both forms entirely agree. The hypothallus becomes possibly more distinct in β, and there conditions more or less the color of the thallus, which varies at length in this form, to brownish. The spores, quite similar in their younger states (varying from 2-5-locular) in both forms, become a little dilated in β, and the sporoblasts (entire in α) are then here and there divided, and thus first indicate the true type of the lichen: exactly as occurs in other spores of the muriform sort, where the same process of differentiation (from narrower and more ellipsoid forms, with entire sporoblasts, to more dilated ones, with subdivided sporoblasts) is observable abundantly in the contents of the same thalamium.

VERRUCARIA DRUMMONDII, sp. nov.: thallo determinato subcartilagineo rugoso-verrucoso ambitu radioso-subplicato nigricanti-fusco hypothallo indistincto; apotheciis minutis verrucis thallinis immersis ostiolo prominulo nigro. Sp. in thecis saccatis (1-2næ?) majusculæ, e cocciformi oblongæ, muriformi-polyblastæ, nigro-fusæ, diam. 1½-3½° longiores. On lime-rock, near Kingston, Canada. The small, rounded, thinnish, and very dark fronds are quite conspicuous on the light-gray rock, and are from a quarter to half an inch in diameter. Thallus warted at the centre, but passing into wrinkles towards the circumference, which is more or less distinctly plaited, and radiant in a manner sometimes approaching that of *Lecidea* (Sporostatia) *Morio*, or, still more, some hypothalline fringes of crustaceous rock-lichens. Apothecia contained in larger, pretty regular warts, the white perithecium finally blackening, especially above. Paraphyses scarcely observable, but the "hymenial gonidia" especially abundant. The

lichen easily reminds one of *Acarospora molybdina*, v. *microcyclos*, Wahl. It belongs to the group represented by *Verrucaria* (Staurothele) *umbrina*, Fr., but is distinguished from that and other allied lichens by the thallus.—Dedicated to the discoverer, A. T. Drummond, Esq., of the Botanical Society of Canada, author of a catalogue of the plants of Canada, now in preparation.

ADDENDA.

PLACODIUM CORALLOIDES, sp. nov.: thallo fruticuloso cartilagineo decumbente vitellino-flavo ramis teretibus subdichotome divisis nodulosis obtusis basi nigricantibus; apotheciis mediocribus lateralibus podicellato-elevatis zeorinis plano-convexis disco saturatori margine tenui integro instructo, thallino mox excluso. Sp. in thecis ventricosos octonæ, oblongo-ellipsoideæ oblongæque, diblastæ sporobl. approximatis, diam. dein $2\frac{1}{2}$ —3° longiores. California, Herb. Gray, growing probably upon rocks. Thallus solid. Thalline margin of the apothecia commonly excluded. Spores comparable rather with those of *P. vitellinum*, more or less oblong, rarely a little oblique, a thin dissepiment sometimes observable, but no trace of an isthmus. Paraphyses thickened and yellowish above. The genus is here taken in the sense of Dr. Stitzenberger (Beitr. z. Flechtensyst. in loco), and includes merely crustaceous as well as effigurate types, which are well brought together by the peculiar differentiation of the spores, and, with some exceptions, by the colors.

PLACODIUM ERYTHRANTHUM. *Lecanora*, Tuckerm. Obs. Lich. l. c. 4, p. 402. Nyl. in Prodr. Fl. N. Granat., Lich. p. 28. In Cuba.

PLACODIUM DIPHASIUM. *Lecanora*, Tuckerm. Suppl. I. l. c. p. 426. In Texas.

PLACODIUM CAMPTIDIUM. *Lecanora*, Tuckerm. Obs. Lich. l. c. 4, p. 403. In Southern Pennsylvania, and southward.

PLACODIUM FLORIDANUM. *Lecanora*, Tuckerm. Obs. Lich. l. c. 4, p. 402. In Florida and Texas.

Five Hundred and Thirty-fourth Meeting.

May 10, 1864. — MONTHLY MEETING.

The PRESIDENT in the chair.

The President called the attention of the Academy to the recent decease of Dr. John Ware of the Resident Fellows, and of General Joseph G. Totten of the Associate Fellows.

Mr. Oliver presented a partial investigation on the best approximate representation of all the mutual ratios of k quantities by those of simple integers.

When $k = 2$, it is well known that the method of continued fractions gives every pair of integers whose ratio is more accurate than that of any simpler pair: [as well as every *proper* approximate ratio, i. e. every approximation $\frac{m_1^{(i)}}{m_2^{(i)}}$ to $\frac{m_1}{m_2}$ in which a certain further criterion that involves either the previous or the next proper approximation, as that $m_1^{(i)} m_2^{(i+1)} - m_2^{(i)} m_1^{(i+1)} = \pm 1$, is satisfied.]

But when $k > 2$, the $\frac{1}{2} k (k - 1)$ separate ratios of the given quantities $(m_1, \dots, m_k)$ can seldom be very accurately represented by those of the same small integers $m_1, \dots, m_k$; and a different kind of criterion is needed to show how far we must rectify either ratio at the expense of others. This *criterion of excellence* depends, of course, on the smallness of some such function V of the $\frac{1}{2} k (k - 1)$ determinants $m_r m_s - m_s m_r^*$ and the $2k$ general magnitudes $(m_1, \dots, m_k)$, as shall be independent of the interchange of (m_r, m_r^*) with (m_s, m_s^*) , and shall vanish when all the determinants do, and not otherwise when $(m_1, \dots, m_k)$ are real and positive. But it remains to fix the precise *form* of V by other considerations; for instance, by the necessities of some particular problem.

Here the simplest case of the problem "to determine the best approximate weights of a set of linear equations," seems likely to give a very natural criterion, whether others equally natural exist or not. Let $(m_1, \dots, m_k)$ be the weights of equations $(x = x_1, \dots, x = x_k)$, from which to determine x .

$$\text{Let} \quad S = m_1 + \dots + m_k, \quad S' = m_1' + \dots + m_k'.$$

* Usually of the *squared* determinants, so as to be independent of the determinants' signs.

If we knew the tensors, but not the signs, of the errors $(e_1, \dots e_k)$ of $(x_1, \dots x_k)$, the consideration that all the 2^k sign-combinations are equally probable, would give for that average or probable increase in the squared error of x due to the inaccuracy of $(m_1, : \dots m_k)$, the value

$$\left(\frac{m_1}{S} - \frac{m_1}{S}\right)^2 e_1^2 + \dots \left(\frac{m_k}{S} - \frac{m_k}{S}\right)^2 e_k^2;$$

but since of $(e_1^2, \dots e_k^2)$ we know only that their probable values are inversely as $(m_1 : \dots m_k)$, on the smallness of

$$\frac{1}{W} = \frac{1}{m_1} \left(\frac{m_1}{S} - \frac{m_1}{S}\right)^2 + \dots \frac{1}{m_k} \left(\frac{m_k}{S} - \frac{m_k}{S}\right)^2$$

must depend the required criterion. Since $\frac{1}{W}$ is here proportioned to the square of the probable effect of the inaccuracy of $(m_1 : \dots m_k)$ upon x , W may be called the *weight* of the approximation $(m_1 : \dots m_k)$ to $(m_1 : \dots m_k)$.

It remains to examine the properties and results of the criterion $F\left(\frac{1}{W}, m_1, \dots m_k\right) = \min.$, where F depends merely on the general magnitudes of $\frac{1}{W}$, m_1 , &c., ...; and to compare them with those of $F\left(\frac{1}{P}, m_1, \dots m_k\right) = \min.$, &c.

It may be said that Nature, while obeying with absolute precision the resultant of her efficient laws, such as Inertia, Attraction, &c., falls into forms which commonly both *utility* and *taste*, often independently of each other, would prescribe; that some of her æsthetic laws can be learned from the simple integers (or other simple members of a series whose form is prescribed *a priori*), whose ratios nearly represent those of certain natural constants; and that the probability that such æsthetic laws are *intentionally* observed may be roughly computed from the constants. Hence the need of some criterion to guide beforehand our selection of approximate ratios, unbiassed by the interests of the special æsthetic law we are testing.

The phyllotaxis, and still more the planetotaxis noticed by Peirce, illustrate one such æsthetic law. The mutual configurations of two planets, and even their separate motions, whether we regard the disturbed orbits as variable ellipses or as higher curves, are patterns containing the element time; and their character must depend mainly

upon those integers whose ratios best represent those of the revolution-periods. This character is probably most peculiar and beautiful, because most distinct, when the period-ratio is

$$\frac{1}{n} + \frac{1}{1} + \dots \frac{1}{1} + \frac{1}{p} \quad [n \text{ an integer, } p \text{ large,}]$$

as in the actual solar system; for were the period-ratio

$$\frac{1}{n} + \dots \frac{1}{a} + \frac{1}{b} + \dots \frac{1}{c} + \dots \quad [n, \dots a, b, \dots c, \dots \text{ integers, } b > 1,]$$

the character due to the ratio $\left(\frac{1}{n} + \dots \frac{1}{c}\right)$ would be somewhat confused and overlaid by that of the lower ratio $\left(\frac{1}{n} + \dots \frac{1}{a}\right)$. Since p is large, the pattern nearly repeats itself after a few revolutions.

Professor Peirce thought that different discussions would require different criteria of excellence in the representation of the constant-ratios involved; and that it would be of interest to determine that form of V which is smallest for those approximate period-ratios which best represent the aggregate of all "terms of long period" in the theory of two or more planets.

Five hundred and thirty-fifth Meeting.

May 24, 1864. — ANNUAL MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read letters relative to the exchanges of the Academy; also a letter from Richard H. Dana, Jr., in acknowledgment of his election into the Academy.

The Report of the Council upon the changes which have occurred in the Academy during the past year was presented, and read in part by the Corresponding Secretary, as follows: —

Since the last Annual Meeting the Academy has received an accession of seventeen new members, viz. five Resident Fellows (two of them in the First Class, one in the Second, and two in the Third Class); seven Associate Fellows (two in the First, one in the Second, and four in the Third Class); and five Foreign Honorary Members, i. e. Professor Graham, of London, in the place of the late Professor Mitscherlich; William Lawrence, of London, in the place of the late Sir Benjamin Brodie; Professor Max Müller, of Oxford, in that of the late Jacob Grimm; Henry H. Milman, the Dean of St. Paul's, in the place of the late Archbishop Whately; and Frederick Overbeck, of Rome, in that of Christian Rauch.

During the year no less than fourteen members have been stricken by death from the ranks of the Academy, — a loss not only numerically large, but noteworthy from the many distinguished names which it embraces. Of this long list four were Resident Fellows, six were Associate Fellows, and four were Foreign Honorary Members of the Academy.

The Resident Fellows thus withdrawn are: Professor Edward Hitchcock and Mr. Francis Alger, of Class II., Section 1, and Dr. George Hayward and Dr. John Ware, of Class II., Section 4.

EDWARD HITCHCOCK, a distinguished member of our Geological Section, elected into the Academy thirty years ago, died at Amherst, on the 27th of February last. He was born at Deerfield, Massachusetts, on the 24th of May, 1793, i. e. exactly seventy-one years ago, received such education as was afforded by the academy of that village, where he early developed a fondness for scientific knowledge, especially for mathematics; he studied theology at New Haven, and was for four years pastor of a church at Conway, Massachusetts. He was called in the year 1825 to the chair of Chemistry and Natural History in Amherst College, — an institution with which his name is inseparably connected, and which, for its general prosperity, no less than for its renowned scientific cabinets, doubtless owes far more to him than to any other individual. He was for almost forty years a Professor, and for ten years President of the College. A list of his publications is appended to a volume which he published shortly before his death, entitled "Reminiscences of Amherst College." These are very numerous and various. "Sixteen volumes and pamphlets," and "fifty-three papers in the journals," are enumerated as scientific productions. All of them which are of permanent interest relate to geology. His

principal contributions to science are contained in his Reports on the Geology of Massachusetts, his papers on Ichnology or Fossil Footmarks in the Connecticut Valley, and his "Illustrations of Surface Geology." The former embody the results of his two official surveys of the State, undertaken, the first in 1832, the last and most elaborate in 1837. The first survey was ordered by the State, at Professor Hitchcock's suggestion. It was (with the exception of an attempt on the part of North Carolina) the inauguration of the long and noble series of State and Territorial Geological Surveys under which the geology, mineral resources, and indeed the whole natural history of North America, have been developed during the last thirty years, and which have produced such important results, both for science and for the material interests of the country. Professor Hitchcock not only explored twice the whole breadth of his native Commonwealth, but was also engaged in the survey of two adjacent States. That of New York, one district of which was consigned to his charge, he gave up at the outset, on account of feeble health. That of Vermont he courageously undertook even in old age, and under increasing infirmities, and, aided by his two sons, he brought it two years ago to a successful issue. His volume entitled "Illustrations of Surface Geology," which passed to a second edition in the year 1860, is supplementary to his Final Report on the Geology of Massachusetts. That portion of it which answers to the title, although only a beginning or a local fragment of a department the facts of which are spread over the whole breadth of the continent, has the merit of being almost the only special investigation of American terraces.

But his scientific fame will mainly rest upon his researches in Ichnology, or the study of fossil footprints; that is, upon his investigations and illustrations of the tracks imprinted by animals, either birds or reptiles, or both, upon the mesozoic rocks of the Connecticut Valley. The late Dr. Deane and Mr. Marsh of Greenfield had, indeed, brought these objects to his notice, and had pronounced them to be the tracks of birds, — for which these gentlemen were entitled to special acknowledgments; but the scientific investigation belonged almost wholly to Professor Hitchcock, and has been, indeed, the most arduous, and perhaps the most important, scientific work of his life. The results of these researches, conducted under considerable disadvantages, from the want of adequate scientific preparation, are embodied in his Final Report on the Geology of Massachusetts; in his extended paper on

"The Fossil Footmarks of the United States," with twenty-four plates, published in the fourth volume of the *Memoirs of this Academy*; in his "Report on the Ichnology of New England," with sixty plates, published by the State, in the year 1858; and in a "Supplementary Report on the Ichnology of Massachusetts," read last year before this Society, and soon to be published by the Commonwealth.

We cannot here call attention to Professor Hitchcock's prolonged services to the cause of education, nor to his various writings upon literary, moral, or religious subjects, many of which have a wide popularity; although, indeed, his numerous published discourses, articles, or volumes upon natural theology, and upon the relations of science to revealed religion, ought not to be overlooked. These, indeed, are characteristic of the man, who was a divine as well as a geologist, not only profoundly convinced that revelation and nature are in essential harmony, but who habitually drew illustrations and arguments from the one for the other with a freedom and confidence that have rarely been equalled. At the age of threescore and ten, under much infirmity, he declares that his "attachment to the works of Nature has all the ardor and enthusiasm of youth"; and also that, as its highest and an unexpected service, "Geology has deepened his convictions of the truth, not only of natural, but of revealed religion." These relations, indeed, were the subjects of his fondest contemplation. He counts it as the great failure of his life that he had been unable to fulfil his long-cherished intention of writing a systematic treatise upon Natural Theology, — a work which, after years of preparation, he "was almost ready to begin," just when his unwilling acceptance of the Presidency of Amherst College — bringing onerous and uncongenial duties upon advancing years and an enfeebled frame — compelled a final abandonment of the undertaking. It may be doubted, however, whether a treatise from his pen would have added much of importance to what is contained in his published essays and articles upon this class of topics, — some of them very elaborate, and in their way excellent, but perhaps none of them so accurately grounded in science, or so closely reasoned, as to answer the difficult questions of the day, or to secure a permanently high rank in this field of inquiry. But this excellent man has himself modestly remarked, that most of his publications "were not written with the expectation that they would go down to posterity, but to aid a little in advancing present knowledge, in adding some items that should go into the general stock; so

that, although the works themselves might be forgotten, some feeble influence at least might remain upon the great cause of learning and religion."

It is almost superfluous to add, that Dr. Hitchcock was a man of extreme simplicity and sincerity of life and character; never disposed to over-estimate himself, nor desirous of being over-estimated by others. But it cannot be doubted that his scientific labors, pursued under many discouragements, with entire singleness, but with much tenacity of purpose, have secured for him an honored name in the records of science. He will be remembered as one of the leading pioneers of New England geology, as one of the original promoters of the system of State and National Geological Surveys, and as essentially the founder of a new department of paleontology. Nor should it be forgotten that he was a prominent originator of the American Association of Geologists and Naturalists; and when this small but spirited organization took the more comprehensive form of the American Association for the Advancement of Science, he continued a conspicuous sharer in its labors and discussions.

FRANCIS ALGER, who was elected into the Academy thirty-two years ago, was born in Bridgewater, Massachusetts, on the 8th of March, 1807. He had only a common-school education, but he was a very intelligent and exact observer of facts and of natural phenomena. His attention was first attracted to mineralogy as early as in the year 1824. Two years afterwards he accompanied his father to Annapolis Basin, in Nova Scotia, where a smelting-furnace was about to be erected for the working of the iron ores of that district. There he collected the first Nova Scotian minerals that were brought to the United States. An account of them was published by him in "The Boston Journal of Philosophy and the Arts," and was reproduced, with some additions, in the American Journal of Science and Arts for 1827. During the summer of that year he, with his friend Dr. Charles T. Jackson, made a more extended mineralogical and geological exploration of Nova Scotia, extending over nearly three fourths of the area of the peninsula. The rich results of these joint labors were published in the fourteenth and fifteenth volumes of the American Journal of Science. In 1829 Mr. Alger and Dr. Jackson made another mineralogical exploration of the Province. Chartering a small vessel, they cruised along the coast of the Bay of Fundy, and obtained a very large supply of beautiful minerals. Specimens of these

were freely distributed to all the public cabinets of Europe, and to many in this country, so that Nova Scotia became widely known as a country in which many rare minerals were found. In 1832 a new and augmented edition of the mineralogical paper by Messrs. Jackson and Alger, illustrated by a geological map and sections, and with sketches of interesting scenery, was published in the *Memoirs of this Academy*.

Several other valuable papers have been published by Mr. Alger, in the *American Journal of Science*, in the *Journal and the Proceedings of the Boston Society of Natural History*, and in the *Proceedings of this Academy*. The most noteworthy are: "Description of Remarkable Crystals of Gold from California, with Drawings,"—a paper that has been more than once republished in Europe; "Description of the Zinc Mines of Sussex County, New Jersey"; "Notices of New Localities of Rare Minerals"; "Minerals of New Holland"; "Beaumontite and Lincolnite identical with Heulandite"; and a paper on the values and permanency of building-stones.

Wishing to republish the mineralogy of William Phillips, with additions bringing it up to the advanced state of the science, Mr. Alger most industriously collected the requisite materials, and performed the laborious work of revising this excellent book, so as to win the applause of mineralogists both in this country and in Europe. This more than editorial labor he performed mostly at night, after his usual mercantile tasks of the day were ended. Soon after the publication of this important work, in 1849, he received from Harvard University the honorary degree of Master of Arts. Mr. Alger intended to produce a new edition of his Phillips's Mineralogy, and had been engaged for years in collecting and digesting the materials. He had secured the donation of the inedited papers of Mr. Phillips, and also those of the late Professor Cleaveland, which he had carefully examined and collated; and his own collections for the republication were very extensive.

In addition to his mineralogical studies, Mr. Alger was much interested in the advancement of the mechanical arts. He invented an improvement in shrapnel, by which the shell was made to explode with greater certainty and with more deadly effect; and he was engaged with officers of the army in testing the merits of his invention when he was seized with the disease which suddenly terminated his useful life. He died at Washington, on the 27th of November, 1863, in the fifty-sixth year of his age.

Mr. Alger was one of the founders, and always an active member, of the Boston Society of Natural History, and he presented to that Society the first specimens of minerals that entered its cabinets. Mr. Alger was a most worthy and benevolent man, zealous in promoting the interests of religious institutions, full of patriotism and public spirit. His manners were gentle and retiring, and it was with great diffidence that he ever spoke in public. He was kind and considerate, and more apt to apologize for the shortcomings of others than to censure or expose them.

GEORGE HAYWARD, M. D., the son of Dr. Lemuel Hayward, of Boston, died suddenly, of apoplexy, October 7, 1863, at the age of seventy-two. He was graduated at Harvard College in 1809, and also received a Bachelor's degree at Yale College. Choosing the profession of his father, he received his medical degree at the University of Pennsylvania, in 1812. Subsequently he had the advantage, at that time rare, of visiting Europe, and of profiting by the instructions of Abernethy, Astley Cooper, and their contemporaries in England and France. On his return, he established himself in his native city, and succeeded to the practice of his father. With this, and an early election as Physician to the Almshouse, he soon gained a high professional position. He became a Fellow of the Massachusetts Medical Society in 1816, shared zealously in its councils during his long career, delivered its Annual Address in 1837, and was chosen its President in 1852, which office he held for several years. He was chosen Assistant Surgeon to the Massachusetts General Hospital, and was one of the Surgeons-in-Chief from 1838 to 1851, — a service of twenty-five years, — and one of the Consulting Surgeons till his death. "The history and records of the Hospital bear enduring testimony to his faithful and devoted labors in all these relations," say the Trustees; who on his retirement complimented him with a request that he would sit for his bust in marble. From 1835 to 1849 he was Professor of Surgery in the Medical Department, and in 1852 was chosen a member of the Corporation, of Harvard University. He became a Fellow of this Academy in 1818. He was an active member of the New England Linnæan Society; was one of the founders of the Boston Society of Natural History, and its first Vice-President, and always maintained a lively interest in its welfare. For many years he was President of the Boston Athenæum, and was ever a liberal patron of science, art, and all liberal culture. When the Medical Commission of Massachusetts was established, to

have a medical oversight of the militia, it was also constituted a Board of Examining Surgeons to decide upon the competency of surgeons for the army; and Dr. Hayward was selected as its chairman, which duty he performed until his death. In none of his various positions did he play an idle or secondary part. As a surgeon he was quick and confident in his decisions and in his operations. In some of the more delicate and unpromising operations he claimed to have originated processes which contributed essentially to their success. Though a few minor operations with the knife had preceded, it was his lot, as one of the surgeons at the Hospital, to perform the first capital operation (the amputation of a leg) under the anæsthetic effects of sulphuric ether, November 7, 1846, — a circumstance which he often alluded to with evident satisfaction. Both in this country and abroad, he strenuously and conscientiously advocated the claims of this agent over all others, on account of its absolute safety. As a teacher, he may not have been so brilliant as some others; but no one excelled him in presenting clearly the fundamental principles of his art, and in imparting sound practical instruction. He was ever zealous for the purity and dignity of his profession, was exceedingly intolerant of every form of empiricism, and was ever zealous in devising and promoting measures for the elevation of the true and the abasement of the false.

While in Europe as a student he began a translation of the writings of Bichat, which, together with the Supplement by Bécclard, were completed and published, in four octavo volumes, in 1818–23. This was the first introduction of the works of the French school to this country. In 1834 he published his “*Outlines of Physiology*.” He was a frequent contributor to the medical journals, and in 1855 he republished many of his papers, with additions, under the title of “*Surgical Reports and Miscellaneous Papers on Medical Subjects*.” All his writings were concise and explicit, and of a strictly practical nature. Among the more important were his “*Surgical Reports on Cases and Operations at the Massachusetts General Hospital*”; on “*Diseases of the Knee-Joint*”; on “*Vesico-vaginal Fistula*”; on “*Anæsthetic Agents*”; on the “*Asiatic Cholera*” (1832), in which he was one of the first to maintain, what is now generally admitted, the non-contagiousness of that disease; and an “*Address to the Public on the Necessity of Legalizing the Study of Anatomy*” (1831), in which he most effectively prepared the public mind for the enactment of a State law to that effect, which was passed quite in advance of any action in any other State of the Union.

JOHN WARE, M. D., died in Boston on the 29th of April, 1864. He was the son of the Reverend Henry Ware, for thirty-five years Professor of Theology in Harvard University, and was born in Hingham, Massachusetts, on the 19th of December, 1795. He was graduated at Harvard College in 1813, received the degree of Doctor of Medicine in 1816, and commenced practice in Duxbury; but in 1817 he removed to Boston, where he resided during the rest of his life. By the force of his excellent qualities and steady devotion to his profession, he gradually acquired an extensive and profitable practice. In 1832 he was appointed Adjunct Professor of Theory and Practice in the Medical Department of Harvard University, and on the resignation of Dr. James Jackson in 1836 he succeeded him in the chair, which he occupied until 1858. In 1848 he was elected President of the Massachusetts Medical Society, which office he held until 1852.*

Dr. Ware belonged to a family eminently distinguished for mental and moral endowments. His father was respected as a scholar and famous as a controversialist. His brother Henry, of whom he wrote a Memoir, was widely known as a preacher and theological writer, and had a decided poetical talent; his brother William, also much esteemed as a preacher, achieved an extended reputation by his classical novels "Zenobia" and "Aurelian." He himself showed a tendency to literary pursuits, one of his earliest publications being a work of imagination. But his life was given mainly to his profession, and his most important writings are connected with the history and treatment

* The following is a list of his principal published writings:—

- 1823. Charles Ashton, a Story.
- 1833. Duties and Qualifications of Physicians. A Lecture.
- 1836. Remarks on the History and Treatment of Delirium Tremens. In the "Medical Communications of the Massachusetts Medical Society."
- 1838. An Appendix to this Essay, in the same publication.
- 1842. Contributions to the History and Diagnosis of Croup. In the "New England Quarterly Journal of Medicine and Surgery."
- 1843. Medical Education. A Lecture.
- 1846. Memoir of Henry Ware, Jr.
- 1847. Condition and Prospects of the Medical Profession. A Lecture.
- 1860. On Hæmoptysis as a Symptom. In the "Publications of the Massachusetts Medical Society."
- 1860. Philosophy of Natural History; being the last of a series of editions of Smellie, to which much important matter was added.

He also published an Essay on the Relations of the Sexes, and various other articles.

of disease. The Essay on Delirium Tremens had a signal influence. The description of the symptoms is very striking, and the views adopted go far towards reducing this affection, which had been thought by many to have found its specific in opium, to the category of self-limited diseases. The dissertation on Croup drew the distinction between the cases with membranous exudation, and those lighter maladies, often confounded with them, in so clear a way, that from the time of its appearance the vital difference between these forms of disease has been universally recognized amongst us. His observations with reference to hæmoptysis, based on long-continued observation of persons who had been subject to it, served to modify some of the sweeping conclusions which had been drawn from the wholesale observation of hospital cases. The style of these and all his writings is plain, easy, and without any affectation or display. He observed carefully, reflected maturely, and then, having fully made up his mind, recorded simply. In his oral teaching he was clear, minute, and explicit, thinking nothing of effect or eloquence, but only how to teach his pupils to know and to treat diseases. As a practitioner he came very near that golden mean where there is faith enough in remedies to leave no means untried that are likely to be useful, and distrust enough of all questionable agencies to guard against the abuse of powerful measures. None could fail to recognize his kindness, his gentleness, his conscientious devotion to the patient; so that the success which his professional skill deserved was made sure by his personal qualities.

His great liberality and candor made him more freely eclectic and generously tolerant than many others whose observation is not more exact, and whose intellects are not clearer than was his own. He would sometimes listen where another might think he could employ his time better; but this was a proof of his fair and evenly-balanced nature, which was always patient with the convictions of others. The verdict of the whole profession to which he belonged, and of the community in the midst of which he lived and labored and died, is, that he was a good and wise man, worthy of love and honor and lasting remembrance. He was faithful to all his duties, a sound thinker, a devoted practitioner, an able writer and teacher; spiritually-minded, yet abounding in practical sense; with an intellect open to wide ranges of thought, yet willing to expend his life in the round of daily services traced out for him by his calling, — a man whose virtues were acknowledged by all who knew him, and who leaves behind him none but gracious recollections.

The Associate Fellows whom we have lost are Professor Joseph S. Hubbard, of Class I., Section 1; Major Edward B. Hunt, of Class I., Section 3; General Joseph G. Totten, of Class I., Section 4; and Dr. Francis Boott, of Class II., Section 2.

JOSEPH STILLMAN HUBBARD, well known for his efficient and thorough work in promoting the progress of astronomy in this country, died in New Haven, on the 16th of August, 1863. He was born in New Haven, September 7th, 1823, and received his education and formed his tastes for mathematical and astronomical pursuits in Yale College, where he was graduated in 1843. He was then for a short time engaged as an assistant in the High School Observatory in Philadelphia, under the distinguished astronomer, Sears C. Walker, and was subsequently employed in the reduction of the astronomical observations of the Rocky Mountain expedition under General Fremont. But it is with the annals of the Naval Observatory at Washington that his career as an astronomer and mathematician is chiefly associated. Appointed a Professor in the United States Navy in the spring of 1846, he was assigned to duty in this Observatory, which was then but recently established, and he remained at this post, a faithful and careful observer, for a period of seventeen years, until the time of his death. With the history and success of this Observatory Professor Hubbard's name is indissolubly connected. In the part which the Observatory took in the memorable discovery of the planet Neptune, it was his good fortune to verify by observation the happy conjecture of Sears C. Walker, that the planet had been observed by the astronomer Lalande as a fixed star, and that a particular star would be found to have disappeared from the place assigned to it in Lalande's Catalogue in 1795, more than fifty years before its discovery as a planet. The Annals of the Naval Observatory contain the chief part of the astronomical publications of Professor Hubbard. In addition to the regular work of an observer, he prepared, in conjunction with Professor Coffin, a valuable series of "Tables for the Reduction of the Places of the Fixed Stars," which were published in an appendix to the observations of 1847. He also prepared a useful table for facilitating the use of Gauss's formulas for ellipses and hyperbolas of which the eccentricities are nearly equal to unity. This was published in the Appendix to the translation of Gauss's *Theoria Motus, &c.*, by Commander (now Admiral) Davis. In all his work he manifested more solicitude for real excellence than for a temporary reputation. Domestic cares, straitened pecuniary

resources, and a predisposition to social occupations rather than to severe studies, prevented him from employing to their fullest extent his powers as a mathematician and astronomer.

Beside his regular contributions to the publications of the Naval Observatory, he communicated from time to time the following papers to Gould's *Astronomical Journal*: "On the Orbit of the Great Comet of 1843," Vol. II., 1852; "Determination of the Orbit of Egeria," Vols. II. and III., 1854; "On the Orbit of Biela's Comet," Vols. III. and IV., 1856; "Correction of Logarithms of A, B, C, and D in the *Tabulæ Regiomontanæ*," Vol. IV., 1856. The articles in *Appleton's American Encyclopædia* on the Telescope and on the Transit-Circle are also from his pen.

EDWARD BISSELL HUNT, a distinguished officer of the United States Engineers, and a most promising man of science, was born at Portage, Livingston County, New York, June 15, 1822. He entered West Point in 1841, and was graduated June 30, 1845, standing second in his class. The next day he was appointed Brevet Second Lieutenant in the Corps of Engineers, and commissioned Second Lieutenant at the close of that year. On the 28th of August, 1846, he was appointed Acting Assistant Professor of Engineering in West Point, and he held that office for three years. Afterwards he was employed on several important fortifications, at Newport, New Haven, New London, &c. He rose by successive promotions to the rank of Major in the Corps of Engineers. At the outbreak of the rebellion he was engaged upon Fort Taylor, at Key West, which will ever stand as an enduring monument of his professional and scientific skill, and which was saved by his energy and sagacity from falling into the hands of the rebels. From 1851 to 1857, while stationed on the New England coast, in the service of the Corps of Engineers and the Light House Board, he also rendered large services to the Coast Survey, and through that work to the general cause of physical science.

He died on the 2d of October, 1863, while experimenting near Brooklyn Navy Yard upon his own invention for piercing the armor of iron-plated ships. Through some accident, the gun-room was filled with the gases from a burning shell, and upon his entering it by a ladder, he was suffocated before effectual help could be rendered.

Major Hunt's personal appearance corresponded to the character of his mind: a noble strength and directness of address, great modesty

combined with perfect self-possession, purity, and kindness of heart, were recognized in him at sight. A closer acquaintance showed that culture had given him also a command of at least all the ordinary resources of the calculus, and that in the investigation of physical and other problems he displayed not only a sound common-sense, but a close metaphysical acumen, which rendered his papers as interesting to the philosophical reader as they were valuable to the man of science. His last publication was an ingenious induction, on scientific grounds, of the perpetuity and perpetual unity of that nation to whose service he had given his powers, and in whose service he finally sacrificed an unexhausted life. A partial list of the papers published by Major Hunt, hereto appended, will show how earnestly, amid the constant duties of his profession, his mind turned toward scientific problems.*

* On the Dispersion of Light. — *Am. Journ. Sci., N. Ser., Vol. VII., May, 1849.*
 On the Interpretation of Mariotti's Law. — *Am. Journ. Sci., Vol. IX., May, 1850.*
 Remarks on Terrestrial Thermotics. — *Am. Association for Advancement of Science, Aug., 1849.*

Proposed Experiments on the Cohesion of Liquids. — *Am. Ass., Aug., 1850.*

On the Use of Air as a Medium for Conveying Mechanical Power. — *Am. Ass., Aug., 1851.*

Proposal for a Trigonometrical Survey of New York. — *Am. Ass., Aug., 1851.*

Views on the Nature of Organic Structure. — *Am. Journ. Sci., Vol. XIII., Jan., 1852.*

Remarks on the Proposed Geographical Survey of New York. — *Am. Journ. Sci., Vol. XIV., July, 1852.*

On Cohesion of Fluids, Evaporation, and Steam-Boiler Explosions. — *Am. Ass., July, 1853.*

Remarks on Lithography and Lithographic Transfer. — *Am. Ass., July, 1843.*

The Conical Condenser; a Telescopic Appendage. — *Am. Journ. Sci., Nov., 1853.*

Project of a Geographical Department of the Library of Congress. — *Am. Journ. Sci., Vol. XVI., Nov., 1853.*

Report of Engraving Operations for 1853. — *Coast Survey Report for 1853.*

Letters describing an Instrument, invented by himself, and called the Inter-ranger. — *Coast Survey Report for 1853.*

Description of the Self-registering Tide-Gauge. — *Coast Survey Report for 1853.*

Notes on Map-Projections. — *Coast Survey Report for 1853.*

Description of the United States Coast Survey Apparatus for Measuring Base Lines. — *Am. Ass., May, 1854.*

On the Nature of Forces. — *Am. Journ. Sci., Vol. XVIII., Sept., 1854.*

Notes on Map-Projections. — *Am. Journ. Sci., Vol. XVIII., Nov., 1854.*

Report on Engraving in Relation to the Coast Survey. — *Coast Survey Report for 1854.*

JOSEPH GILBERT TOTTEN, late the veteran head of the United States Engineer Corps, died at Washington, on the 22d of April last. He was born at New Haven, Connecticut, on the 23d of August, 1788, entered the United States Military Academy at West Point in 1803, as one of the thirteen cadets of which the school then consisted, and

General List of Coast Survey Discoveries and Developments to 1853 inclusive. — Coast Survey Report for 1854.

Condensed Alphabetical Index of the Ten Annual Coast Survey Reports, from 1844 to 1853 inclusive. — Coast Survey Report for 1854.

On the Use of Salt Marsh Sods for Facing the Steep Slopes of Parapets, Terraces, &c. — Am. Ass., August, 1855.

On an Index of Papers on Subjects of Mathematical and Physical Science. — Am. Journ. Sci., Vol. XX., Nov., 1855.

On our Sense of the Vertical and Horizontal, and on our Perception of Distance. — Am. Journ. Sci., Vol. XX., Nov., 1855.

On Efflorescence from Brick Masonry. — Am. Ass., August, 1856.

On Systematizing the Abbreviations of Titles of Periodicals, Transactions, &c., Am. Ass., August, 1856.

Report of an Index of Reference to Memoirs and Papers on subjects related to the Coast Survey Operations. — Coast Survey Report for 1856.

On the Idea of Physical and Metaphysical Infinity. — Am. Journ. Sci., Vol. XXV., Jan., 1858.

Views and Suggestions on the Practice and Theory of Scientific Publication. — Am. Journ. Sci., Vol. XXVI., July, 1858.

Notes on a New Sounding Apparatus proposed by himself for Coast Survey Use. — Am. Journ. Sci., Vol. XXVI., Sept., 1858.

Report on the Preparation of an Index of Scientific References. — Coast Survey Report for 1857.

On the Dynamics of Ocean Currents. — Am. Jour. Sci., Vol. XXVII., March, 1859.

On some Anomalies in the Florida Gulf Stream, and on their Further Investigation. — Am. Journ. Sci., Vol. XXVII., March, 1859.

Description of the new Portable Coffey Dam. — Am. Ass., Vol. XIV., Aug., 1860.

New Method of Preventing Fire-Damp Explosions in Collieries, by Lighting with Coal Gas. — Am. Ass., Vol. XIV., Aug. 1860.

Modern Warfare: its Science and Art. — New Englander, Vol. XVIII., Nov., 1860.

Union Foundations: a Study of American Nationality as a Fact of Science. — Pamphlet published in New York, Jan., 1863.

On the Origin, Growth, Substructure, and Chronology of the Florida Reef. — Am. Journ. Sci., Vol. XXXV., March, 1863.

Key West Physical Notes. — Am. Journ. Sci., Vol. XXXV., May, 1863.

was graduated in 1805, receiving the commission of Second Lieutenant of Engineers on the first of July of that year.

He soon resigned from the Corps of Engineers to take the position of Assistant to his uncle, Professor Jared Mansfield, who was then Surveyor-General, and had in charge the first systematic survey of the Northwestern Territory, which at that period included the present State of Ohio. The impress of young Totten's military education, however, remained. He returned to the Corps in February, 1808, and during the ensuing war with Great Britain went through a distinguished career. He was Chief Engineer under Major-General Macomb, in the campaign of 1814, on the northern frontier of New York; and he won the brevet of Major, September 11, 1814, "for gallant conduct at the battle of Plattsburg." In September, 1824, he was brevetted Colonel; in 1838, he was commissioned. As Chief Engineer he accompanied Major-General Scott to Mexico, and was brevetted Brigadier-General, on the 29th of March, 1847, "for gallant and meritorious conduct" at the siege of Vera Cruz. Just before his death, the President of the United States nominated him to the Senate as a Major-General, and that body immediately confirmed the nomination.

Thus General Totten's whole life, from his sixteenth year to the seventy-sixth, was chiefly devoted to the Engineer service of the United States. "In that period, and especially in the last few years of his life, he made many experiments in the leading elements of his profession; amongst others, on the penetrability of walls by the force of cannon-shot, bringing engineers back to consider the use of a well-known fact, namely, that earthen profiles were more sure and more lasting resistors of heavy projectiles than masonry."

Among his excursions from the domain of military engineering were the examinations of the growth of the sandy coast-line of the Southern States of the Union on the Atlantic and Gulf of Mexico; the use of jetties to control the growth of the coast; the complex changes of harbors and shores; the preservation of islands, of river shores, of wharves, etc., from encroachment, as at Portland, Boston, New York, Cape Fear Entrance, Charleston, Fernandina, Pensacola, and Mobile. For these labors, executed without remuneration, he received the thanks of the Legislature of New York, of the City Councils of Portland and Boston, and of the Board of Trade of New York.

Next to his own profession and to the studies incident to it, his attention was most attracted to natural history, and especially to

conchology, geology, and mineralogy. Fond of exercise and of occupation, bodily and mental, he made his walks and drives both conducive to his robust health and subservient to these scientific pursuits, in which he accumulated a large amount of knowledge, and evinced powers of observation and research of no common order. His genial nature always inclined him to place at the disposal of others, and especially of the assistants under his command, all the treasures and resources which he had garnered; and this was done more in the spirit of the elder brother, or head of a family, than as a superior officer. His personal influence and example stimulated and led on to improvement the educated young men who from time to time came into his military family. He marked out or suggested to them subjects of research, mostly of a practical kind, and methods of experiment; and always encouraged any disposition in them towards originality of thought; and so freely and generously imparted his own conceptions to his assistants while stimulating theirs, that they might well have been persuaded that many of the ideas originated with themselves. His laboratory was at their service, no less than his example and companionship. An enumeration of his principal professional researches, could they here be given, would illustrate the mental thoroughness, the complete devotion, and the eminently practical character of this excellent and genial man.

General Totten was elected, first by Congress, one of the Regents of the Smithsonian Institution at its foundation in 1846, and was continued in the Board of Regents by successive elections held every sixth year thereafter. During the entire period he was constant in his services as a member of the Executive Committee of the Board. He was also a member of the Light-House Board created by Congress in 1852, and one of the most useful of its working members, as Chairman of the Committee of Engineering and of Finance.

"For the past twenty-six years he has been at the head of the Engineer Department, administering with untiring devotion, spotless integrity, and signal ability, the varied duties, the financial responsibilities, and the professional labors of that arm of service, so essential to our national defence."

FRANCIS BOOTT, M. D.,—whom we claim as a New England naturalist, although elected into the Academy long after he took up his residence in London,—died in that city on Christmas last, in the seventy-first year of his age. His father, Kirk Boott, who came from

England in early life, was a well known and successful Boston merchant. His brother, Kirk Boott, Jr., was one of the pioneers of the manufacturing enterprise at Lowell. Francis Boott, the third son, was born in Boston on the 26th of September, 1792; was graduated at Harvard College in 1810; passed the four succeeding years in England; and, returning to this country in the year 1814, with his scientific tastes awakened, he was mainly occupied for the next six years in investigating the botany of New England. In the summer of 1816, he, in connection with Dr. Bigelow, undertook the botanical exploration of the higher mountains of New England, and in one tour ascended Wachusett, Monadnock, Ascutney, and Mount Washington, the latter at that time to be reached only by a laborious journey of two days on foot. They were accompanied upon this at that time formidable expedition by our late associates, Chief Justice Shaw and Francis C. Gray. An interesting account of the ascent of Mount Washington was published at the time in the *New England Journal of Medicine and Surgery*, by Dr. Bigelow, now the sole survivor of the party.

In the year 1820, at the age of twenty-eight, having determined to adopt the medical profession, Mr. Boott crossed the Atlantic for the last time, and, proceeding to London, became a pupil of the late Dr. Armstrong. He continued his medical studies in the University of Edinburgh, where he took the degree of M. D. in 1824. He then went to Paris for a year, studying in the schools of medicine and of natural history, and forming the acquaintance of the eminent French naturalists of that period. He soon after established himself in London as a physician, and also as Lecturer on Botany and *Materia Medica* in the Webb Street School of Medicine, in connection with his preceptor and near friend, Dr. Armstrong. Upon the early death of Dr. Armstrong, he became his biographer and expositor, and published in 1834, after several years' preparation, in two octavo volumes, his "*Memoir of the Life and Medical Opinions of John Armstrong, M.D.*, to which is added an Inquiry into the Facts connected with those Forms of Fever attributed to Malaria and Marsh Effluvium," — a work which excited considerable attention. He had before published two Introductory Lectures on *Materia Medica*. He was an active promoter of the establishment of the London University (now University College), and was for more than a quarter of a century an influential member of its Senate and Council. He had been elected a Fellow of the Linnæan

Society as early as in the year 1819, under the Presidency of its founder, his friend, Sir James Edward Smith ; and afterwards he served it continuously for the last twenty-five years of his life as Secretary, Treasurer, or Vice-President. Nearly thirty years ago he was offered the vacant Chair of Natural History in Harvard University. But the ties of family and of a large circle of attached friends bound him to England. About this time, gradually relinquishing medical practice, he began to devote himself to the study of the intricate genus *Carex*, one of the largest and most difficult genera of the vegetable kingdom. This genus, so admirably illustrated by Schkuhr at the beginning of this century, has since attracted the particular attention of American botanists, as is shown by the caricological writings of Muhlenberg, Schweinitz, and of our surviving associates, Dewey and Torrey. But since the publication of Dr. Boott's account of the British-American Carices, in Sir William Hooker's *Flora Boreali-Americana*, in 1840, he has been the unrivalled head of this department. In his principal work, entitled "Illustrations of the Genus *Carex*," he has accomplished for this genus, now that its known species are nearly six hundred, what was done by Schkuhr half a century ago, when less than a quarter of these species were known, and has done it upon a far grander scale, and with unparalleled fulness of illustration. Three folio volumes of this great work, with over four hundred plates, have been produced within the last six years ; and a fourth volume, left incomplete when his long enfeebled strength finally gave way, is about to be published by his family. To this work Dr. Boott devoted not only many years of assiduous labor, but a large sum of money ; the drawings, engravings, and letter-press having been produced at his sole expense, while the larger part of the copies have been freely presented to those, both in Europe and in this country, who were most interested in the subject. It has, therefore, been well said to be "one of the most munificent contributions ever made to scientific botany, besides being one of the most conscientious and scrupulously accurate,—on which account it certainly entitles its author to take a much higher place among botanists than that of an amateur, which is all his modesty would allow him to lay claim to."

Modesty, scrupulous accuracy, entire disinterestedness, a winning simplicity and cordial frankness, were characteristics of Dr. Boott. Most of our naturalists and professional men who have visited England within the last thirty years can testify to the kind, even affectionate

interest which he took in them, and in the furtherance of their pursuits. His published works will suffice to secure for his name an honorable and permanent place upon the records of science. * But only his contemporaries and friends will know how much he has done to help others, and how disinterestedly and gracefully that aid was ever rendered.

The Foreign Honorary Members whose eminent names now disappear from our roll are Baron Plana, Professor Mitscherlich, Professor Henry Rose, Jacob Grimm, and Archbishop Whately. To these must be added the name of the eminent Russian mathematician, Ostrogradsky, of whose death during the preceding year the Academy was not informed until after the last Annual Meeting.

Baron GIOVANNI PLANA, Senator and Director of the Royal Observatory at Turin, died on the 20th of January last, at the age of eighty-two.

He was born at Voghera, Piedmont, November 8th, 1781, but removed to France in his childhood. He entered the *École Polytechnique* at Paris in 1800, taking the rank of eighth among the candidates admitted. The instructions and influence of Monge, of Lagrange, Laplace, and Legendre, must have contributed powerfully to determine the direction given to his powers, which afterwards proved him no unworthy successor of these illustrious men. While yet very young, he received an appointment as Professor in the Military School of Alessandria, near his native town. Subsequently he became Professor of Astronomy and of the Higher Mathematics in the University of Turin, Director of the Royal Observatory, and President of the Academy of Sciences. In 1821-23, he was associated with Carlini in the measurement of the arc of the meridian in Savoy and Piedmont. The account of the plan and execution of this work, prepared by Plana, received the Lalande prize of the French Institute.

The numerous memoirs given to the world by Plana during his long and active career, embracing a great variety of investigations in the more difficult departments of physics, pure mathematics, and astronomy, testify to the versatility of his talents, and the unwearied industry with which they were exercised. Everywhere the treatment is by the hand of a master, and the subject receives some important advancement; yet it did not fall to his lot to attach his name to any of those brilliant discoveries which are the foundation of scientific fame. In point of number, his researches in astronomy, even including those

upon subjects only indirectly related to the science, would perhaps furnish the titles of scarcely the half of his published writings; but they include those by which his name has been most widely known. His celebrated criticisms upon the theory of the planetary perturbations, as developed in the *Mécanique Céleste*, where he boldly called in question the authority of Laplace upon a subject which had afforded to that renowned geometer one of the most brilliant of his triumphs, were alone sufficient to show his confidence in his own powers, and to place him in a position of prominence before the scientific world which only abilities of the highest order could have sustained; nor was this the only occasion on which he exercised great freedom of criticism in charging theoretical errors upon the same author.

His attention seems to have been early directed to the Lunar Theory. Already in 1813 he was seriously contemplating its discussion in conjunction with Carlini. The principle on which it was proposed to conduct this discussion may be designated as the *literal* solution of the problem, where the coefficients of the inequalities are expressed in theoretical form, in contradistinction to the *numerical* solution, in which they are derived from observation. Plana zealously maintained the former method to be the only solid basis of the Lunar Theory, even carrying the fervor of his advocacy to the extent of characterizing the rival system, exhibited in its highest perfection in the Lunar Tables of Hansen, as “un pas rétrograde sous le rapport de la théorie.”

In 1820, a prize, suggested by Laplace, was announced by the Institute for the construction of Lunar Tables, so far as possible, from theory alone. This was adjudged in 1828, by a commission consisting of Laplace, Burchardt, and Poisson, to be divided between Plana, Carlini, and Damoiseau. The memoir of Plana and Carlini has never been published, but it was probably incorporated, to a considerable extent, in the “*Théorie du Mouvement de la Lune*,” published by Plana in 1832, — a monument of genius and of the most indefatigable industry, triumphing over difficulties of which, to use his own words, it is impossible to form the least conception “sans avoir soi-même parcouru l’immense océan qui sépare le point de départ et le point d’arrivée.”

A supplement to the “*Théorie de la Lune*” appeared in 1857; and he was still vigorously prosecuting, in his eightieth year, the investigations entered upon almost half a century earlier. Even at a still later

period he was actively engaged in profound scientific labors, the announcement of his latest memoirs scarcely preceding the intelligence of his decease. Few more striking examples have occurred of the preservation and the advantageous employment of intellectual powers of the highest order so far beyond the ordinary term of human life.

The two renowned chemists, whose names are now removed from our list, Mitscherlich and Rose, are naturally associated. They were born nearly at the same time, studied together under the same master, were Professors throughout the greater part of their lives at the same University, and died within a few months of each other. But with all these external coincidences in the character of their minds and in their influence upon science, they were widely different; so that, had either been longer spared to us, he would in no wise have made good the loss of the other.

EILHARD MITSCHERLICH died on the 28th of August, 1863. He was born in 1794, in Neurede, a small town near the German Ocean, in the Province of East Friesland, at that time belonging to Prussia. He finished his chemical studies at Stockholm, in the laboratory of Berzelius, and was shortly afterwards, in 1822, made Professor at the University of Berlin. He here published, in 1829, a text-book upon Chemistry,—a work of much originality, and which has retained its reputation to the present day.

Mitscherlich's attention was early directed to the connection between crystalline form and chemical composition; and he had the singular fortune, in his twenty-fifth year, to discover the law which expresses their relation. With this discovery his name has become identified; and in turn it seems to have given the direction to his thoughts and to the more important of his works. As is usually the case, the way to this discovery was already prepared by the labors of others. It had been laid down by Haüy as a law, that, with the exception of those substances which crystallize in the regular system, a difference in chemical composition must necessarily be attended by a difference in crystalline form; and it was thought impossible that the same body could assume two distinct primitive forms. The truth of the former of these views was contested by numerous observers about the beginning of the present century. It was shown as early as 1787 by Leblanc, that from a solution containing the sulphates of iron and of copper crystals may be obtained which have precisely the same form, and yet

contain the two salts in very different proportions. And Bernhardt, while agreeing with Haüy that each substance can assume but *one* primitive form, admitted that different substances may possess the *same* primitive form; and also, that a body may have the power to impress upon another with which it is mingled its own peculiar crystalline shape. Finally, in his theory of "vicarious constituents," — bodies which are capable of replacing each other in combination without thereby inducing a change of form, — Fuchs had made a near approach to the theory of Isomorphism.

It remained for Mitscherlich, by collating and generalizing the views of those who had gone before him, and by largely adding to the facts which they had accumulated, to develop this law; nor did he at first perceive it in its true light. In his second memoir Mitscherlich says: "Do different elements take the same crystalline form when combined with the same number of atoms of one, or of several other elements? Is identity of crystalline form dependent solely upon the number of atoms? Is it independent of the chemical nature of these atoms? Accident leading me at first to investigate a series of compounds which answered all these questions in the affirmative, I was on the point of regarding my results as a general law. But on extending my researches to other combinations, . . . I found that this identity does not necessarily follow." And he was finally led to the view that "certain elements, when united with the same number of atoms of one or of several elements, assume the same crystalline form; and that the elements may in this respect be divided into groups."

If to this be added the property of the elements in the several groups to replace each other in varying proportions in a compound, without materially changing its crystalline form, we have the true expression of the law of Isomorphism.

The discovery of Isomorphism showed that the first axiom of Haüy was inexact, and required an essential modification; the discovery of Dimorphism, made at the same time, completely overturned Haüy's second axiom. It is a proof of the sagacity displayed by Mitscherlich in these researches, that, in the long time which has elapsed since they were made, his deductions have received no important alteration; even his own genius could in after life only add to the facts upon which the conclusions arrived at in his youth were founded. The importance of his results to chemistry and mineralogy was at once appreciated; while their very brilliancy has obscured his subsequent works.

HEINRICH ROSE died at Berlin, on the 28th of January last. Nearly half a century of Professor Rose's life was devoted to the unremitting and successful cultivation of pure science. In attempting to form an opinion of any one scientific work so long ago completed, we find a difficulty in representing to ourselves the circumstances under which it was composed, — in rightly apprehending the state of science at the time. The difficulty is still greater of forming a correct idea of what would have been the present state of chemical science, had labors like those of Rose, on the most varied subjects, and extending through a long lifetime, never been undertaken. Few of these works led to great or brilliant discoveries; most of them resulted in those gradual additions to knowledge which necessarily follow a patient and well-directed course of inquiry. But it is precisely to such labors, which have prepared the way and the age for the reception of great truths, that science is in the end indebted for their discovery.

Heinrich Rose was born at Berlin on the 6th of August, 1795; consequently, at his death he had not completed his sixty-ninth year. His father and grandfather were apothecaries and chemists in Berlin; the latter a man of considerable reputation, and the discoverer of the fusible alloy which goes by the name of Rose's Metal. In the discourse which H. Rose delivered before the Berlin Academy, in memory of Berzelius, he tells us: "I had the good fortune in my youth to assist the celebrated Klaproth in his chemical operations, but only in the last years of his life, in the summer of 1816, when his labors were interrupted by frequent and severe illness."

In 1819 Rose went to Stockholm, and worked for a year and a half in the laboratory of Berzelius.

In 1823 he was appointed Professor of Chemistry in the University of Berlin; and he retained and fulfilled the duties of this station until his death.

The writings of Rose consist of his Treatise on Analytical Chemistry, and of a very great number of papers published at first in Gilbert's, and then in Poggendorff's Annals. His Analytical Chemistry is the work by which he is best known. Without claiming to be a treatise upon the theory or the operations of chemistry in general, it includes them both, so far as they are required for the purposes of analysis. From its precision and completeness it not only superseded all the earlier works on this subject, but even caused them to be forgotten. Of his papers, some are single essays, devoted to special points of

chemistry; others, of a more general nature, and extending in series through one or more volumes of the *Annals*, are researches upon the composition of, or the reactions which characterize, different groups of chemical compounds. So various, indeed, are these subjects, that there is hardly an element for some portion of our knowledge of which we are not indebted to Heinrich Rose. It is therefore impossible to give an analysis of works whose mere titles would require more space than is allotted by custom to the memory of our distinguished associates. Much of what was afterwards arranged in its proper place in his *Analytical Chemistry*, appeared originally as contributions to the *Annals*.

The most remarkable of these papers is a series which extends, with interruptions, through more than fifteen years, and contains the history of his discovery of the metal Niobium. The points of interest of this investigation are obscured by its great detail, and by the repetitions, and sometimes inconsistencies, inevitable in a work prosecuted at long intervals. From the different specific gravities of the several varieties of the mineral called Tantalite, as well as of the metallic acids contained in them, Rose was led to believe that these acids were the oxides of different metals. He at first assumed the existence of two new metals, which he called Niobium and Pelopium, and which, by uniting with oxygen, gave rise to the niobic and pelopic acids. Further examination showed, however, that these acids contained but one metal, which was combined in them with different proportions of oxygen. But the one of these acids could in no way be directly converted into the other; they comport in so many respects like the oxides of two similar but different metals, that for a long time he so regarded them. The metal obtained from these acids is the same, whether the one or the other of them has been employed; but when the metal is again oxidized, there is formed always the one, never the other, of the two acids. When the metal from either of the acids is made to combine with sulphur, which it does in several proportions, and the resulting sulphuret is reconverted by oxidation into acid, the acid is invariably the same as that from which the sulphuret was formed. "This is a phenomenon," says Rose, "to which there is no analogy in chemistry. For the two acids act, not like the oxides of one and the same metal, but like oxides of two different metals. The tendency to the formation of the one or the other of the acids must have existed beforehand in the metal itself. The inquiry had touched upon ground which is as yet hidden from us by

an impenetrable veil; and this it is which has led me to devote so much labor and time to the subject."

The discovery of a new element is apt to be attended with an *éclat* which its scientific importance does not always warrant. The combinations of the niobic and pelopic acids have little chemical interest, and they are found in such small quantities that few chemists can have the opportunity of investigating them. It was not until Rose had shown that these supposed new bodies were two forms of one and the same element, differing from each other as no two forms of the same matter were known to differ, that the real importance of his discovery was made evident, and that he was rewarded for those years of persevering and sagacious research. To the close of his life, and under the trial of domestic affliction, Rose's interest in science remained unabated. In his last years, and apparently conscious that his life was not to be much prolonged, he published a series of papers under the title of "Contributions to Analytical Chemistry." They contain the results of his latest experiments, and his views upon several points of this his favorite subject. His latest work appeared only a few months before his decease. Not inappropriate to Rose himself are the words with which he concludes his notice of the life of his master, Berzelius: "The labors of such men present to us the true model of the man of science."

JACOB GRIMM, the venerable German philologist, was born at Hanau, January 4, 1785. He was educated in the Lyceum at Cassel, and afterwards in the University of Marburg, where he studied law under Savigny. He did not, however, engage in professional life as a jurist, but devoted himself with passionate ardor to the study of mediæval literature and antiquities, especially those of his own country. For a number of years his studies were more or less interrupted by public employments. In 1814 he was appointed Hessian Secretary of Legation, and in that capacity attended the Congress of the Allied Powers at Vienna. But from this time forward he renounced political life, except that, more than thirty years later, in 1848 and 1849, he was a member of the National Assembly in Frankfort and Gotha. From 1816 to 1829, he was Second Librarian at Cassel. From 1830 to 1837, he was Professor and Librarian in Göttingen. When the King of Hanover set aside the Constitution which had been given to his subjects, he was one of the seven Professors who protested against the act, and in consequence was not only deprived of his office, but, with

Gervinus and Dahlmann, was banished from the country. After four years spent in retirement at Cassel, he was called to Berlin in 1841, as Member of the Academy, with the privilege of lecturing in the University. In these changes of residence and service, he was accompanied by his brother Wilhelm, who was but one year younger than he, and who shared, though with a less vigorous and ardent nature, in the same studies and pursuits. A few years after coming to Berlin, they commenced in common the gigantic undertaking of a German Dictionary, to contain all words found in German literature since the era of the Reformation, with definitions and copious citations.

While they were engaged in this work, Wilhelm Grimm, after a few months of declining health, died, December 16, 1859: he was commemorated by his brother in a pathetic address delivered before the Berlin Academy. For nearly four years longer, Jacob Grimm continued to work on by himself, in an old age of more than seventy-five years, but with hardly any abatement of activity and power. At length the call of death came unexpectedly: a stroke of apoplexy terminated his honorable and useful life, September 20, 1863, in the seventy-ninth year of his age.

In the scientific career of Grimm we may trace the patriotic reaction caused in the mind of Germany by the conquests of Napoleon. His studies and labors were comprehensive and multifarious; but Germany was the centre of them all. It was not, however, Germany in the narrow sense that engaged his attention: his interest extended to all sections and members of the Germanic race. They are all represented in what we must regard as the great work of his life, the "*Deutsche Grammatik*," of which the first volume was published in 1819, and the fourth in 1837; a fifth, which was to complete his plan, never appeared. It is a work of prodigious research, containing an immense amount of scientific material, which had to be collected by the author himself, with scanty help from previous laborers in the field. It is no less distinguished for the originality and boldness of its conception. No scholar had before produced a comparative grammar, embracing a number of related languages, and showing how the same primitive scheme of inflection and structure presents itself in each. It is difficult to overestimate the acuteness and sagacity which enabled Grimm to trace out a unitary system amid the seeming irregularity and confusion of the phenomena he had to deal with. In his "*Geschichte der Deutschen Sprache*" (2 vols., 1848), the lights of philology are used to explore

the darkness of German antiquity, to show the early civilization, settlements, and migrations of the Germanic races. Of his "Deutsches Wörterbuch" we have already spoken; though the master's hand was arrested in the middle of his work, it is hoped that his collections of material will fall to successors who, working in his spirit and with the guidance of his example, will worthily complete this great monument of his genius and learning.

But Grimm was no mere student of words. To him grammar and lexicography were means, not ends. He saw manifested in them the mind of the German people; and all manifestations of the Germanic mind attracted his attention and awakened his sympathy. This we see in many extensive and laborious works which issued from his study, such as his "Deutsche Rechtsalterthümer" (1828), his "Deutsche Mythologie" (1835), his "Deutsche Weisthümer" (3 vols., 1840-42), and not least in the "Kinder- und Hausmärchen," published jointly by himself and his brother Wilhelm, which has endeared their names to the children of all countries. A strong poetic sensibility was among the characteristics of Grimm's mind. He loved the old German poetry, and read it again and again with the keenest relish. In publishing the remains of the early German literature, he rendered important service by his "Reinhart Fuchs" (1834), his Anglo-Saxon "Andreas und Elene" (1840), his "Gedichte des Mittelalters auf König Friedrich I." (1844), etc.

These and other important works, such as his numerous papers published in scientific and literary journals, and in the transactions of learned societies, — papers always characterized by great ingenuity and laborious research, — may serve to show that it is no empty vaunt when Grimm says of himself that there is in his nature a certain iron industry. At the same time, it is clear that no industry, however tough and plodding, could have accomplished such results, without the qualities of quickness and acuteness, which Grimm possessed in a high degree. His acuteness was conspicuous in his conversation, which is described as singularly pithy and racy, full of unexpected turns and striking suggestions. His quickness also was extraordinary. His books were written with great rapidity, and were printed just as they were written, without first draught and corrected copy. Composed in this way, they are of course wanting in literary finish. They have not the simplicity and transparency which can only come by careful elaboration.

RICHARD WHATELY, D.D., Archbishop of Dublin, died at his official residence, October 8, 1863, aged seventy-six years. He was born in London, and educated at Oxford, where he received his first degree in 1808. Three years afterwards, he was elected a Fellow of Oriel College, an institution which then became, under the able management of its Provost, Dr. Coplestone, the most distinguished school of speculative philosophy in England. Among Whately's contemporaries or immediate successors there were Davison, Hampden, Hawkins, Keble, Arnold, the elder Newman, and Pusey; and he was wont to allude with commendable pride to the fact, that there were, at one time, no less than seven Bishops of the Established Church, viz. four English, two Irish, and one Colonial, who had been members of this one small College. Vacating his fellowship by marriage in 1821, he became Rector of Halesworth, in Suffolk; but his admirable qualifications for academic life and labor were already so well known, that, after only four years' absence, he was recalled to the University by an unsolicited appointment as Principal of St. Mary's Hall. In this position he remained till 1831, when Earl Grey, then Prime Minister, appointed him Archbishop of Dublin, believing that he was the fittest person in the United Kingdom, not only to take the lead in the Irish Church, but to forward the great scheme of National Education in Ireland, and, as an indispensable preliminary to its success, to establish more amicable relations between Catholics and Protestants in that divided country. This was an enterprise hedged round with peculiar difficulties and perils; but through Dr. Whately's discretion, energy, and perseverance, it was successfully carried forward for over twenty years. He showed a rare union of literary talent, knowledge of human nature, and administrative ability; and the work that he accomplished places him in the highest rank of Christian statesmen.

The published writings of Archbishop Whately were numerous, and upon a great variety of topics. He was almost equally distinguished as a theologian, and as a writer upon the Evidences of Christianity, and the sciences of logic, rhetoric, and political economy. In theology, though he cannot be called the founder of a school, he was an independent and original thinker, always inclining to the side of liberal opinions, but prompt and efficient in the advocacy of all which he regarded as constituting the essential doctrines of his Church. His "Essays upon some of the Peculiarities of the Christian Religion," "On some of the Difficulties in the Writings of the Apostle Paul," "On the

Kingdom of Christ," and in refutation of Tractarianism, have had a wide influence upon the course of religious thought in England for more than a quarter of a century. His "Treatise upon Logic" attained an unexampled circulation both in England and this country, and was the chief means of rescuing the study of that science from the neglect in which it had languished for nearly two centuries. The corresponding treatise upon Rhetoric has almost equal merits; while the admirable little textbooks on "Money Matters," "The Evidences of Christianity," and "The British Constitution," which he prepared for the use of the Irish National Schools, are the productions of a Christian philosopher, filling one of the highest offices in the Church, who was not too proud to assist in teaching the humblest of the poor. It ought not to be forgotten, also, that he was even munificent in his charities, though his income was but scanty for an Archbishop, and that he was wholly disinterested in bestowing his patronage, giving but a very modest preferment to his only son.

The great popularity and influence of his writings are attributable in a considerable degree to the merits of his style, which has often been compared with that of Paley. It is clear, unpretending, and forcible, abounding with homely but apposite illustrations, which have frequently the effect of wit. He appears more as a teacher than an author, repeating the truths which he deems important over and over again in his different works, and always more regardful of the effect to be produced, and the principles to be inculcated, than of what might be thought of his own manner and intentions. His own character peeps out in an unconscious and amusing manner, especially in his later works, but always in a way to command the respect, and even the affection, of his readers. He manifests perfect simplicity and heartiness, and that sort of good nature which the French call *bonhomme*; he quotes his own writings frequently, and is so eager to impress upon others the doctrines which he thoroughly believes and deems of the highest interest, that his manner might sometimes be chargeable with dogmatism. He was a thinker, rather than a great scholar; the truths which he was most anxious to present were not those which he had found in books, or which related to the interpretation or the enforcement of other people's thoughts, but those which he had evolved from his own researches and meditations, and on which he had dwelt so long that they assumed in his eyes what was perhaps an exaggerated importance. He acquired that influence in his Church, in his own dio-

cese, and over his contemporaries generally, which never fails to attend the efforts of a disinterested and indefatigable worker, who is eager to impart to others the convictions which have strongly affected his own mind and conduct.

Perhaps Dr. Whately overestimated the importance of mere reasoning, — of holding up truth in the clearest light and supporting it by the most convincing arguments. He was always a logician, aiming much more to convince than to persuade. Even rhetoric, according to his acceptation of the term, was not much more than a department of applied logic, or a science of the discovery and right use of arguments. Of mere oratory he was impatient, and had only a feeling of contempt for fine and eloquent writing. He was a Christian Rationalist, in the highest and best sense of that term, always aiming to furnish a reason for the faith that was in him. He accomplished enough to leave behind him the reputation of which he himself would have been most desirous ; — that of an author whose writings have contributed largely to the instruction and improvement of his countrymen ; and of a prelate whose name will long be honored, not only in his own Church, but by all Christian denominations, for the liberality of his opinions, and for his successful advocacy of religious truth and exemplification of it in his own life and character.

A list of the members of the Academy, arranged under their several sections, and corrected up to the present date, is appended to this report. It appears that there are now one hundred and seventy Resident Fellows, seventy-eight Associate Fellows, and seventy-one Foreign Honorary Members.

In conclusion, the Council submitted nominations to fill vacancies in the list of Foreign Honorary Members made by the decease of MM. Plana, Ostrogradsky, and Rose.

The Annual Report of the Treasurer, attested by the Auditors, was read, accepted, and ordered to be entered on the records. On motion of the Treasurer the following vote was passed : —

“Whereas certain banks in which the Academy owns stock have become, or are about to become National Banks, our Treasurer is hereby authorized to exchange said stock for equal amounts of stock in the said National Banks respectively.”

The Treasurer in behalf of the Finance Committee recommended that the same appropriations as for the preceding year be made from the General Fund.

Professor Lovering, the chairman, presented a report from the Rumford Committee, and in accordance with its recommendations the following votes were passed: —

1. That the sum of six hundred dollars be paid from the income of the Rumford Fund for the purchase of *Meyerstein's Spectrometer*, and *Regnault's Apparatus for Measuring the Tension of Vapors*, to be used by Professor Wolcott Gibbs for special investigations on Light and on Heat; the results of these investigations to be communicated to the Rumford Committee to be offered by them for publication in the "Memoirs of the American Academy of Arts and Sciences."

2. That the sum of two hundred dollars be paid from the income of the Rumford Fund for the purchase of glass prisms, to be used by Professor J. P. Cooke in investigations on the metallic spectra; the results of these investigations to be communicated to the Rumford Committee, to be offered by them for publication in the "Memoirs of the American Academy of Arts and Sciences."

Professor Lovering, as chairman of the Committee of Publication, presented a report accounting for expenditures in printing the Memoirs and Proceedings under the appropriations of the last annual meeting.

Professor Lovering also presented a report from the Rumford Committee in relation to the published works of Count Rumford.

In accordance with the recommendations of the special committee to whom was referred the subject of a revision of certain Statutes of the Academy, it was voted that the second Section of Chapter IX. be amended so as to read as follows: —

"Candidates for election as Resident Fellows must be proposed by two or more Resident Fellows, in a recommendation signed by them, specifying the section to which the nomination is made; which recommendation shall be read at a stated meeting, and then stand on the

nomination list at least ten weeks, and until the balloting. No person shall be elected a Resident Fellow unless he shall have been resident in this Commonwealth one year next preceding his election; and any one so elected, who shall have resided out of the Commonwealth for the term of five years, and shall have discontinued the payment of his assessments during that time, shall be deemed to have abandoned his fellowship; provided, nevertheless, that this abandonment of fellowship for non-residence shall not apply to persons engaged in the service of the State, or of the United States."

It was also voted that the 1st Section of Chapter X. be amended so as to read as follows:—

"All proposed alterations of the Statutes, or additions to them, shall be referred to a committee, and on their report at a subsequent meeting, shall require for enactment a majority of two thirds of the members present, and at least eighteen affirmative votes."

The following additions to the Standing Votes of the Academy were also passed.

To be added to the second Vote:—

"And the current issues of the Proceedings shall be supplied, when ready for publication, free of charge, to all the Fellows and Members of the Academy, who desire to receive them."

New Vote, to be the third in order:—

"The Committee of Publication shall fix from time to time the price at which the publications of the Academy may be sold. But members may be supplied at half this price with volumes which they are not entitled to receive free, and which are needed to complete their sets."

New Vote, to be the fourth:—

"One hundred extra copies of each paper accepted for the Memoirs of the Academy shall be separately printed, of which fifty shall be placed at the disposal of the author, free of charge."

Dr. J. B. Upham of Boston was elected a Fellow in Class II., Section 4.

The annual election resulted in the choice of the following officers for the ensuing year.

ASA GRAY, *President*.

CHARLES BECK, *Vice-President*.

WILLIAM B. ROGERS, *Corresponding Secretary*.

CHAUNCEY WRIGHT, *Recording Secretary*.

EDWARD WIGGLESWORTH, *Treasurer*.

JOSIAH P. COOKE, *Librarian*.

Council.

THOMAS HILL,	} of Class I.
GEORGE P. BOND,	
JOHN B. HENCK,	
AUGUSTUS A. GOULD,	} of Class II.
LOUIS AGASSIZ,	
JEFFRIES WYMAN,	
ROBERT C. WINTHROP,	} of Class III.
GEORGE E. ELLIS,	
ANDREW P. PEABODY,	

Rumford Committee.

JOSEPH LOVERING,	JOSEPH WINLOCK,
MORRILL WYMAN,	WOLCOTT GIBBS,
WILLIAM B. ROGERS,	CYRUS M. WARREN.

Committee of Finance.

ASA GRAY,	} <i>ex officio</i> , by statute.
EDWARD WIGGLESWORTH,	
J. INGERSOLL BOWDITCH, by appointment.	

The other Standing Committees were appointed on nomination of the President, as follows:—

Committee of Publication.

JOSEPH LOVERING,	JEFFRIES WYMAN,
CHARLES BECK.	

Committee on the Library.

AUGUSTUS A. GOULD, WILLIAM P. DEXTER.
JOHN B. HENCK.

Committee to audit the Treasurer's Accounts.

THOMAS T. BOUVÉ, CHARLES E. WARE.

LIST

OF THE FELLOWS AND FOREIGN HONORARY MEMBERS,

MAY 24, 1864.

FELLOWS.

CLASS I. — *Mathematical and Physical Sciences.*

SECTION I.

Mathematics.

William P. G. Bartlett,	Cambridge.
Ezekiel B. Elliott,	Boston.
William Ferrel,	Cambridge.
Benjamin A. Gould,	Cambridge.
John B. Henck,	Boston.
Thomas Hill,	Cambridge.
Simon Newcomb,	Washington.
James E. Oliver,	Lynn.
Edward Pearce,	Cambridge.
Benjamin Peirce,	Cambridge.
James M. Peirce,	Cambridge.
John D. Runkle,	Cambridge.
Thomas Sherwin,	Dedham.
Chauncey Wright,	Cambridge.
Joseph Winlock,	Cambridge.

SECTION II.

Practical Astronomy and Geodesy.

George P. Bond,	Cambridge.
J. Ingersoll Bowditch,	Boston.
Alvan Clark,	Cambridge.
Charles Henry Davis,	Cambridge.

William Mitchell,	Lynn.
Maria Mitchell,	Lynn.
Robert Treat Paine,	Boston.
Henry C. Perkins,	Newburyport.
C. H. F. Peters,	Clinton, N. Y.
Truman H. Safford,	Cambridge.
George Searle,	Brookline.

SECTION III.

Physics and Chemistry.

Joseph Hale Abbot,	Beverly.
John Bacon,	Boston.
John H. Blake,	Boston.
William F. Channing,	Providence.
Thos. Edward Clark,	Williamstown.
Josiah P. Cooke, Jr.,	Cambridge.
Samuel L. Dana,	Lowell.
William P. Dexter,	Roxbury.
Charles W. Eliot,	Cambridge.
Moses G. Farmer,	Salem.
Wolcott Gibbs,	Cambridge.
Augustus A. Hayes,	Boston.
Albert Hopkins,	Williamstown.
Eben N. Horsford,	Cambridge.
Joseph Lovering,	Cambridge.

Francis Peabody,	Salem.
Edward S. Ritchie,	Boston.
Frank H. Storer,	Boston.
Cyrus M. Warren,	Boston.

SECTION IV.

Technology and Engineering.

Henry L. Abbot,	Cambridge.
Edward C. Cabot,	Boston.
Henry L. Eustis,	Cambridge.
James B. Francis,	Lowell.

James Hayward,	Boston.
Charles Jackson,	Boston.
John C. Lee,	Salem.
William R. Lee,	Roxbury.
Charles S. Storrow,	Boston.
William H. Swift,	New York.
John H. Temple,	Boston.
Sylvanus Thayer,	Braintree.
Daniel Treadwell,	Cambridge.
William Watson,	Cambridge.
Morrill Wyman,	Cambridge.

CLASS II. — *Natural and Physiological Sciences.*

SECTION I.

*Geology, Mineralogy, and Physics
of the Globe.*

Thomas T. Bouvé,	Boston.
Jonathan P. Hall,	Boston.
Charles T. Jackson,	Boston.
Jules Marcou,	Cambridge.
Henry D. Rogers,	Boston.
William B. Rogers,	Boston.
Charles U. Shepard,	Amherst.
Josiah D. Whitney,	Northampton.

SECTION II.

Botany.

Jacob Bigelow,	Boston.
George B. Emerson,	Boston.
Asa Gray,	Cambridge.
John A. Lowell,	Boston.
John L. Russell,	Salem.
Charles Jas. Sprague,	Boston.
Edward Tuckerman,	Amherst.

SECTION III.

Zoölogy and Physiology.

Alex. E. R. Agassiz,	Cambridge.
Louis Agassiz,	Cambridge.
Thomas M. Brewer,	Boston.
Henry Bryant,	Boston.

Samuel Cabot,	Boston.
Henry James Clark,	Cambridge.
John Dean,	Boston.
Silas Durkee,	Boston.
Augustus A. Gould,	Boston.
Samuel Kneeland,	Boston.
Theodore Lyman,	Brookline.
Charles Pickering,	Boston.
D. Humphreys Storer,	Boston.
David Weinland,	Cambridge.
Henry Wheatland,	Salem.
Jeffries Wyman,	Cambridge.

SECTION IV.

Medicine and Surgery.

Samuel L. Abbot,	Boston.
Henry J. Bigelow,	Boston.
Henry I. Bowditch,	Boston.
Benjamin E. Cotting,	Roxbury.
Calvin Ellis,	Boston.
Oliver W. Holmes,	Boston.
James Jackson,	Boston.
John B. S. Jackson,	Boston.
Edward Jarvis,	Dorchester.
Reuben D. Mussey,	Boston.
Charles G. Putnam,	Boston.
Edward Reynolds,	Boston.
Horatio R. Storer,	Boston.
Charles E. Ware,	Boston.
J. Mason Warren,	Boston.

CLASS III. — *Moral and Political Sciences.*

SECTION I.

Philosophy and Jurisprudence.

William Allen,	Northampton.
George T. Bigelow,	Boston.
Francis Bowen,	Cambridge.
John Henry Clifford,	New Bedford.
Benjamin R. Curtis,	Boston.
Richard H. Dana, Jr.,	Cambridge.
Mark Hopkins,	Williamstown.
Charles G. Loring,	Boston.
Joel Parker,	Cambridge.
Theophilus Parsons,	Cambridge.
George Putnam,	Roxbury.
William A. Stearns,	Amherst.
Benjamin F. Thomas,	Boston.
James Walker,	Cambridge.
Emory Washburn,	Cambridge.

SECTION II.

Philology and Archaeology.

Ezra Abbot,	Cambridge.
Albert N. Arnold,	Hamilton, N.Y.
Charles Beck,	Cambridge.
Epes S. Dixwell,	Cambridge.
Charles Folsom,	Cambridge.
William W. Goodwin,	Cambridge.
Ephraim W. Gurney,	Cambridge.
Horatio B. Hackett,	Newton.
William Jenks,	Boston.
George M. Lane,	Cambridge.
George Livermore,	Cambridge.
George R. Noyes,	Cambridge.
Chandler Robbins,	Boston.
James Savage,	Boston.
Nathaniel B. Shurtleff,	Boston.
E. A. Sophocles,	Cambridge.
Samuel Swett,	Boston.
Joseph E. Worcester,	Cambridge.

SECTION III.

Political Economy and History.

Caleb Cushing,	Newburyport.
George E. Ellis,	Charlestown.
Edward Everett,	Boston.
Levi Lincoln,	Worcester.
J. L. Motley,	Boston.
Francis Parkman,	Boston.
A. P. Peabody,	Cambridge.
Willard Phillips,	Cambridge.
Josiah Quincy,	Boston.
Jared Sparks,	Cambridge.
Henry W. Torrey,	Cambridge.
Robert C. Winthrop,	Boston.

SECTION IV.

Literature and the Fine Arts.

Charles F. Adams,	Boston.
William T. Andrews,	Boston.
George S. Bontwell,	Groton.
Francis J. Child,	Cambridge.
Jos. G. Cogswell,	Cambridge.
Ralph Waldo Emerson,	Concord.
John B. Fitzpatrick,	Boston.
Nath'l L. Frothingham,	Boston.
John C. Gray,	Boston.
Richard Greenough,	Boston.
Charles C. Jewett,	Boston.
Henry W. Longfellow,	Cambridge.
Francis C. Lowell,	Boston.
James Russell Lowell,	Cambridge.
Charles Eliot Norton,	Cambridge.
Octavius Pickering,	Cambridge.
William W. Story,	Boston.
George Ticknor,	Boston.
Edward Wigglesworth,	Boston.

ASSOCIATE FELLOWS.

CLASS I. — *Mathematical and Physical Sciences.*

SECTION I.

Mathematics.

Charles Avery, Clinton, N. Y.
 Alexis Caswell, Providence, R. I.
 Wm. Chauvenet, St. Louis, Mo.
 Charles Davies, New York.
 Jeremiah Day, New Haven, Conn.
 H. A. Newton, New Haven, Conn.
 William Smyth, Brunswick, Maine.
 Theodore Strong, N. Brunswick, N. J.

SECTION II.

Practical Astronomy and Geodesy.

S. Alexander, Princeton, N. J.
 Alex. D. Bache, Washington, D. C.
 W. H. C. Bartlett, West Point, N. Y.
 J. H. C. Coffin, Newport, R. I.
 Wm. H. Emory, Washington, D. C.
 J. M. Gilliss, Washington, D. C.
 Jas. D. Graham, Washington, D. C.
 Elias Loomis, New Haven.
 Charles Wilkes, Washington, D. C.

SECTION III.

Physics and Chemistry.

F. A. P. Barnard, New York.
 Joseph Henry, Washington, D. C.
 T. Sterry Hunt, Montreal, Canada.
 John LeConte, Columbia, S. C.
 W. A. Norton, New Haven, Conn.
 John M. Ordway, Manchester, N. H.
 Charles G. Page, Washington, D. C.
 Ogden N. Rood, New York.
 Benj. Silliman, New Haven, Conn.
 Benj. Silliman, Jr., New Haven, Conn.

SECTION IV.

Technology and Engineering.

Richard Delafield, Washington, D. C.
 A. A. Humphreys, Washington, D. C.
 Dennis H. Mahan, West Point, N. Y.
 George G. Meade, Philadelphia.
 S. F. B. Morse, Poughkeepsie, N. Y.
 George Talcott, Albany, N. Y.

CLASS II. — *Natural and Physiological Sciences.*

SECTION I.

Geology, Mineralogy, and Physics of the Globe.

James D. Dana, New Haven, Conn.
 J. W. Dawson, Montreal, Canada.
 Edward Desor, Neufchatel.
 John C. Fremont, New York.
 Arnold Guyot, Princeton, N. J.
 James Hall, Albany, N. Y.
 F. S. Holmes, Charleston, S. C.
 J. Peter Lesley, Philadelphia.
 Sir W. E. Logan, Montreal.
 Geo. E. Swallow, Columbia, Mo.

SECTION II.

Botany.

Moses A. Curtis, Hillsboro, N. C.
 Chester Dewey, Rochester, N. Y.
 Geo. Engelmann, St. Louis, Mo.

W. S. Sullivant, Columbus, Ohio.
 John Torrey, New York.

SECTION III.

Zoölogy and Physiology.

John Bachman, Charleston, S. C.
 Spencer F. Baird, Washington, D. C.
 J. C. Dalton, New York.
 Jno. E. Holbrook, Charleston, S. C.
 J. P. Kirtland, Cleveland, Ohio.
 John L. LeConte, Philadelphia.
 Joseph Leidy, Philadelphia.
 St. J. Ravenel, Charleston, S. C.

SECTION IV.

Medicine and Surgery.

Isaac Hays, Philadelphia.
 Wm. Sweetser, Burlington, Vt.
 Geo. B. Wood, Philadelphia.

CLASS III. — *Moral and Political Sciences.*

SECTION I.

Philosophy and Jurisprudence.

L. P. Hickok, Schenectady, N. Y.
 Alonzo Potter, Philadelphia.
 Francis Wayland, Providence, R. I.

SECTION II.

Philology and Archæology.

S. P. Andrews, New York.
 James Hadley, Jr., New Haven.
 S. S. Haldeman, Columbia, Pa.
 George P. Marsh, Burlington, Vt.
 Alph. S. Packard, Brunswick, Maine.
 Edward E. Salisbury, New Haven.
 William D. Whitney, New Haven.
 Theodore D. Woolsey, New Haven.

SECTION III.

Political Economy and History.

Sam. G. Arnold, Newport, R. I.
 George Bancroft, New York.
 Henry C. Carey, Philadelphia.
 Francis Lieber, New York.

SECTION IV.

Literature and the Fine Arts.

Wm. C. Bryant, New York.
 Hiram Powers, Florence.
 Fred. E. Church, New York.
 J. P. Kennedy, Baltimore.

FOREIGN HONORARY MEMBERS.

CLASS I. — *Mathematical and Physical Sciences.*

SECTION I.

Mathematics.

John C. Adams, Cambridge.
 George B. Airy, Greenwich.
 Sir Wm. R. Hamilton, Dublin.
 Hansen, Seeberg.
 Le Verrier, Paris.
 Liouville, Paris.
 Sir J. W. Lubbock, London.

SECTION II.

Practical Astronomy and Geodesy.

Argelander, Bonn.
 Encke, Berlin.
 Sir J. F. W. Herschel, Bart., London.
 Peters, Altona.

William H. Smyth, London.
 W. Struve, St. Petersburg.

SECTION III.

Physics and Chemistry.

Sir David Brewster, Edinburgh.
 Dumas, Paris.
 Michael Faraday, London.
 Thomas Graham, London.
 Christopher Hansteen, Christiania.
 Liebig, Munich.
 Regnault, Paris.

SECTION IV.

Technology and Engineering.

Charles Babbage, London.
 Sir William Fairbairn, Manchester.
 Fourneyron, Paris.

CLASS II. — *Natural and Physiological Sciences.*

SECTION I.

Geology, Mineralogy, and Physics of the Globe.

Elie de Beaumont,	Paris.
Duperrey,	Paris.
Dove,	Berlin.
Sir Charles Lyell,	London.
Sir R. I. Murchison,	London.
Quetelet,	Brussels.
Adam Sedgwick,	Cambridge.
De Verneuil,	Paris.

SECTION II.

Botany.

Decaisne,	Paris.
Alph. DeCandolle,	Geneva.
Elias Fries,	Upsal.
Sir Wm. J. Hooker,	Kew.
John Lindley,	London.
Von Martius,	Munich.
Von Mohl,	Tübingen.

SECTION III.

Zoölogy and Physiology.

Von Baer,	St. Petersburg.
Theod. L. W. Bischoff,	Munich.
Ehrenberg,	Berlin.
Milne-Edwards,	Paris.
Albrecht Kölliker,	Wurtzburg.
Richard Owen,	London.
C. Th. von Siebold,	Munich.
Valentin,	Berne.

SECTION IV.

Medicine and Surgery.

Andral,	Paris.
Louis,	Paris.
Rayer,	Paris.
Rokitansky,	Vienna.
William Lawrence,	London.

CLASS III. — *Moral and Political Sciences.*

SECTION I.

Philosophy and Jurisprudence.

Cousin,	Paris.
Mittermaier,	Heidelberg.
Trendelenburg,	Berlin.
William Whewell,	Cambridge.

SECTION II.

Philology and Archæology.

Bekker,	Berlin.
Boeckh,	Berlin.
Bopp,	Berlin.
Eyriès,	Paris.
Pascual de Gayangos,	Madrid.
Max Müller,	Oxford.

Lepsius,	Berlin.
Duke di Serradifalco,	Palermo.

SECTION III.

Political Economy and History.

Guizot,	Paris.
George Grote,	London.
John Stuart Mill,	London.
Henry H. Milman,	London.
Leopold von Ranke,	Berlin.

SECTION IV.

Literature and the Fine Arts.

Gino Capponi,	Italy.
J. J. da Costa de Macedo,	Lisbon.
Overbeck,	Rome.

Five hundred and thirty-sixth Meeting.

June 14, 1864. — ADJOURNED ANNUAL MEETING.

The PRESIDENT in the chair.

Mr. F. H. Storer was elected a member of the Rumford Committee, to fill the vacancy left at the annual election.

Professor Goodwin presented the following papers: —

I. *Note on Thucydides, I. 22.*

In the following passage of Dionysius of Halicarnassus (*Art. Rhetor.* XI. 2, p. 398 R.) we find the original of the famous saying, *History is philosophy teaching by examples*. (See Bolingbroke's *Letters on History*, No. 2, p. 14.)

Παδεία ἄρα ἐστὶν ἡ ἐντευξις τῶν ἡβῶν. τοῦτο καὶ Θουκυδίδης ζοικε λέγειν, περὶ ἱστορίας λέγων ὅτι καὶ ἱστορία φιλοσοφία ἐστὶν ἐκ παραδειγμάτων. “Ὅσοι δὲ βουλήσονται τῶν τε γενομένων τὸ σαφὲς σκοπεῖν καὶ τῶν μελλόντων ποτὲ αὖθις κατὰ τὸ ἀνθρώπειον τοιούτων καὶ παρπλησίων ἔσσεσθαι ὠφέλιμα,” χρῆσθαι ταῖς παλαιαῖς ἱστορίαις.

It will be seen that Dionysius professes to give merely the idea contained in the passage quoted from the preface of Thucydides (I. 22). That passage, however, as it stands in our editions of Thucydides, contains no such idea. It reads: ὅσοι δὲ βουλήσονται τῶν τε γενομένων τὸ σαφὲς σκοπεῖν καὶ τῶν μελλόντων ἔσσεσθαι, ὠφέλιμα κρίνειν αὐτὰ ἀρκούντως ἔξει. It is commonly translated, *I shall be well content, if so many as shall wish to have a clear view, not merely of the past, but also of what will in all human probability be like or analogous (to the past) in the future, shall judge my work (αὐτά) to be profitable*. The difficulties in the way of this interpretation are wellnigh insuperable, and one of the acutest modern editors, Krüger, gives up the passage, in his last edition, as utterly hopeless. At all events, it is certain that Dionysius found a very different idea in the passage as it stood in his day. It will be noticed that he makes the word ὠφέλιμα a part of the relative clause introduced by ὅσοι βουλήσονται. This suggests at once a slight change in the punctuation of the common text of Thucydides, which will, we think, remove the chief difficulties both in construction and sense. We propose to remove the comma after ἔσσεσθαι and to insert it after κρίνειν, so that the construction shall be: ὅσοι βουλήσονται τῶν τε γενομένων τὸ σαφὲς σκοπεῖν καὶ τῶν μελλόντων ὠφέλιμα κρίνειν, αὐτὰ ἀρκούντως ἔξει. The phrase τῶν μελλόντων ὠφέλιμα κρίνειν will mean

to draw (i. e. from the past) *useful inferences for the future*, the genitive μελλόντων being used with ὠφέλιμα for the sake of parallelism with τῶν γενομένων τὸ σαφές. We consider ὠφέλιμα a kindred accusative after κρίνειν, the phrase being equivalent to κρίσιν ὠφέλιμον κρίνειν, which no one will think too harsh a construction for Thucydides, especially in such an involved sentence. Compare PLAT. Rep. II. 360 E: τὴν κρίσιν κρίναι ὀρθῶς, and N. Test. JOH. VII. 24: τὴν δικαίαν κρίσιν κρίναι, *judge righteous judgment*. See also LUC. XX. 47: μακρὰ προσεύχονται, *they make long prayers*. The omission of the antecedent of ὅσοι is illustrated by THUC. I. 82: ἀνεπίφθορον δέ, ὅσοι ὥσπερ καὶ ἡμεῖς ὑπὸ τῶν Ἀθηναίων ἐπιβουλεύομεθα. The whole passage will then read:—

Καὶ ἐς μὲν ἀκρόασιν ἴσως τὸ μὴ μυθῶδες αὐτῶν ἀτερπέστερον φανέται· ὅσοι δὲ βουλίσσονται τῶν τε γενομένων τὸ σαφές σκοπεῖν καὶ τῶν μελλόντων ποτὲ αὖθις κατὰ τὸ ἀνθρώπειον τοιούτων καὶ παραπλησίων ἔσεσθαι ὠφέλιμα κρίνειν, αὐτὰ ἀρκούντως ἔξει. κτῆμά τε ἐς ἀεὶ μᾶλλον ἢ ἀγώνισμα ἐς τὸ παραχρήμα ἀκούειν ξύνκειται, *And while for hearing it recited the absence of fables in it (my history) will perhaps appear less agreeable; still it will be satisfactory as it is (αὐτά, notwithstanding the τὸ μὴ μυθῶδες) for all who shall wish not merely to have a clear view of the past, but also to draw useful inferences in regard to events which will hereafter in all human probability be like or analogous (to the past). And it is composed as a possession for all time, rather than as a mere prize essay to be listened to for the moment.*

Having (as we think) interpreted the passage in Thucydides by the help of Dionysius, we may perhaps restore the passage in Dionysius from Thucydides. It is clear that the construction is defective, as it now stands; for ὠφέλιμα can hardly be governed by σκοπεῖν, and that certainly was not the construction used by Thucydides. We must therefore simply restore the last word κρίνειν to the quotation in Dionysius, and govern χρῆσθαι by λέγει (or some such word) understood; so that the sense shall be, *he tells all such persons (i. e. ὅσοι βουλίσσονται, κ. τ. λ.) to study history.*

II. Notes on two Passages in the Second Philippic of Demosthenes.

1. In Demosthenes, Phil. II. § 35 (p. 74, 6–10), we find the following passage in all the older editions: ἔκαστον ὑμῶν, καίπερ ἀκριβῶς εἰδότα, ὅμως ἐπαναμνησθαι βούλομαι τίς ὁ Φωκέας καὶ Πύλας πείσας ὑμᾶς προέσθαι, κ. τ. λ. Most modern editors, including Bekker and Dindorf,

retain the same reading, transposing the words *πείσας* and *ὑμᾶς* variously in accordance with different manuscripts, none of which are of the highest authority. The last words are interpreted, whatever order is followed, *who persuaded you to abandon the Phocians and Thermopylae?* There is no great difficulty in applying this to the inaction of the Athenians at the time of the ratification of their treaty with Philip in 346 B. C., when Philip was marching upon their friends, the Phocians. Demosthenes had just referred (§ 30) to his own vigorous attempts to rouse the Athenians to action at that time: — *προὔλεγον καὶ διεμαρτυρούμην καὶ οὐκ εἶων προέσθαι Πύλας οὐδὲ Φωκέας*, — a passage to which the corruption of § 30 in the inferior MSS. is perhaps due.

But in the passage from § 35 (quoted above) the word *ὑμᾶς* is omitted in the best two MSS. (Σ. and Aug. 1); and in Σ., whose single authority ought to be above appeal in such a case, we have *ποιήσας* substituted for *ὑμᾶς*, the order being *τίς ὁ Φωκέας πείσας καὶ Πύλας ποιήσας προέσθαι*. In Σ. we have also *ἐπαναμνησέσθαι* for *ἐπαναμνήσαι*. In Voemel's larger edition of the public orations of Demosthenes (*Demosthenis Contiones, Graece et Latine*, Halis Saxonium, 1857) we find both these corrections adopted from Σ.; but the translation shows that the editor still retains the interpretation of the old text, considering the rejected *ὑμᾶς* as still understood with both participles. He translates: *unusquisque vestrum, licet probe gnarus, tamen etiam revocet velim sibi in memoriam, quis suaserit ut Phocenses, quis fecerit ut Pylas proieceritis*. Westermann in his school edition adopts the same text, but has no note to show that he suspects the common interpretation. It would hardly have occurred to any one who was not familiar with the ordinary reading and interpretation to translate *τίς ὁ Φωκέας πείσας καὶ Πύλας ποιήσας προέσθαι* in any other way than, *who was it who persuaded the Phocians and caused them to abandon Thermopylae*. A slight reference to the circumstances of Philip's passage of Thermopylae will show that nothing else could have been meant by Demosthenes. The orator tells us (Fals. Leg. § 58, p. 359) that, when the embassy reached Athens, Philip had already presented himself at Thermopylae and was making promises to the Phocians who held the pass, in the hope of being admitted without opposition. The Phocians put no faith in Philip's promises, but sent to Athens for advice. Their ambassadors were present in the very Athenian assembly in which Aeschines made his pretended disclosures of Philip's real intentions towards the Phocians, and they

returned in the full belief that Philip would pass Thermopylae as their friend. 'Ηγούντο, οὐδ' εἰ δεκάκις Φίλιππος αὐτοὺς ἐξηπάτα, οὐδέποτε' ἂν τοὺς γε Ἀθηναίων πρέσβεις Ἀθηναίους ἐξαπατᾶν τολμήσαι, ἀλλ' εἶναι ταῦτ' ἀληθῆ ἃ οὗτος ἀπήγγελλε πρὸς ὑμᾶς, καὶ τοῖς Θηβαίοις ἦκεν οὐχ αὐτοῖς ὀλεθρον. (Fals. Leg. § 53.) On their arrival the pass was *surrendered* to Philip by a regular convention, and all the cities in Phocis were surrendered peaceably into his hands. The following passages from Demosthenes (Fals. Leg. §§ 61 – 63) will remove all doubts: —

Ἔτι τοῖνυν τὸ μηδεμίαν τῶν πόλεων τῶν ἐν Φωκεύσιν ἀλῶναι πολιορκία μέγιστόν ἐστι σημεῖον τοῦ διὰ τούτους πεισθέντας ὡς ὑπὸ τοῦ Φιλίππου σωθήσονται ταῦτα παθεῖν· οὐ γὰρ ἐκείνόν γε ἡγνύουν.

Ἀκούετε, ὦ ἄνδρες Ἀθηναῖοι. ὁμολογία Φιλίππου καὶ Φωκέων, φησὶν, κ. τ. λ. Καὶ πάλιν παραδοῦναι δὲ τὰς πόλεις Φωκέας φησὶ Φιλίππῳ, οὐχὶ Θηβαίοις οὐδὲ Θετταλοῖς οὐδὲ ἄλλω οὐδενί. διὰ τί; ὅτι Φίλιππος ἀπηγγέλλετο πρὸς ὑμᾶς ὑπὸ τούτου (i. e. Aeschines) ἐπὶ τῇ τῶν Φωκέων σωτηρίᾳ παρεληλυθέναι. τούτῳ δὴ πάντ' ἐπίστανται, καὶ πρὸς τοῦτον πάντ' ἐσκόπουν, πρὸς τοῦτον ἐποιοῦντο τὴν εἰρήνην.

2. In the same oration, § 27 (p. 72, 12), we find in most editions this passage: ἀλλ' ὑμεῖς οἱ καὶ συνιέντες αὐτοὶ καὶ τῶν λεγόντων ἀκούοντες ἡμῶν ὡς ἐπιβουλεύεσθε, ὡς περιστοιχίζεσθε, ἐκ τοῦ μηδὲν ἤδη ποιῆσαι λήσεθ', ὡς ἐμοὶ δοκεῖ, πάνθ' (πάντα ταῦτα οἱ πάντα) ὑπομείναντες. Here Σ. reads ὥστε μηδὲν ἤδη ποιεῖν λήσεσθ', κ. τ. λ. No editor, however, has adopted this reading, except Voemel in the Halle edition above mentioned, and he gives the passage an interpretation which we think the words will hardly bear. We venture, therefore, to call attention to it as more Demosthenic than the common reading. It seems hardly possible that any one can have been deterred from accepting this reading by any difficulty in interpreting ὥστε μηδὲν ἤδη ποιεῖν. We need merely refer to PLAT. Gorg. 479 C: πᾶν ποιοῦσιν, ὥστε δίκην μὴ διδόναι, *they do everything, to avoid suffering punishment*, where ὥστε μὴ διδόναι is almost equivalent to the final clause, ἵνα μὴ διδῶσιν. The whole sentence will thus mean: *but you, — who not only understand for yourselves, but also learn from us orators, how you are plotted against, how you are encompassed by toils, — in order to avoid immediate action, will, it seems to me, insensibly submit to everything.*

We should hesitate to accept the form λήσεσθ', for λήσεθ', with the participle without better authority, especially as $\sigma\theta$ (the abbreviation for $\sigma\theta$) and θ would be so easily confused. Even if we admitted the middle form here, we should consider it as equivalent to λήσετε in its

neuter sense; Voemel, however, translates *λήσεσθε πάνθ' ὑπομείναντες*, *immemores eritis omnia vos tolerasse*, and gives the following note: *oblivio priorum malorum praeceptum imprudentiae et desidiaae signum est*. But the aorist participle with *λανθάνω*, *τυγχάνω*, and similar verbs, seems to have no more force as a past tense than the aorist subjunctive or imperative does; see *εὐλαβεῖσθαι μὴ λήσετε διαφθαρέντες*, *to take care lest you shall find yourselves insensibly corrupt*, PLAT. Gorg. 487 D; *βουλοίμην ἂν λαθεῖν αὐτὸν ἀπελθών*, *to get off without his knowing it*, XEN. AN. I. 3, 17; *τοὺς ἀνθρώπους λήσομεν ἐπιπεσόντες*, AN. VII. 3, 43. With such verbs the present participle is used in its ordinary sense, denoting a continued action, while the aorist expresses a momentary act coincident with that of the verb, and the perfect seems to have been used when a special reference to the past was required in the participle. Thus, *ἔτυχον ὀπλῖται καθεύδοντες*, *soldiers happened to be sleeping*, THUC. IV. 113; *στρατιὰ ἔτυχε παρελθοῦσα*, *an army happened to march*, VI. 61; *ἐτίγγχανον οἱ στρατηγοὶ ἄρτι παρειληφότες τὴν ἀρχήν*, *the generals happened to have just assumed their authority*, VI. 96; *ἐάν τις ἡδικῆκώς τι τυγχάνῃ τὴν πόλιν*, *if it shall happen that any one has done any wrong to the city*, DEM. Cor. § 123. So *λήσετε πάνθ' ὑπομείναντες* will not mean, *you will forget that you have endured everything*, but *you will insensibly (before you know it) submit to everything*.

Dr. A. A. Gould presented the Annual Report of the Librarian, which was accepted, and a recommendation to increase the salary of the Assistant Librarian was referred to the Finance Committee.

DONATIONS TO THE LIBRARY,

FROM MAY 27, 1863, TO MAY 24, 1864.

Boston Society of Natural History.

Journal. Vol. VII. No. 4. 8vo. Boston. 1863.

Museum of Comparative Zoölogy, Cambridge.

Bulletin. 8vo pamph. 1863.

Astronomical Observatory of Harvard College.

Annals. Vol. IV. Part 1. 4to. Cambridge. 1863.

Report of the Committee of the Overseers of Harvard College, appointed to visit the Observatory in the Year 1862; together with

VOL. VI.

35

the Report of the Director, submitted January 29, 1863. 8vo pamph. Boston. 1863.

Essex Institute.

Proceedings. Vol. IV. No. 1. January, February, March, 1864. 8vo. Salem.

American Antiquarian Society.

Proceedings of the American Antiquarian Society at the Semi-annual Meeting in Boston, April 29, 1863. Proceedings at the Annual Meeting held in Worcester, October 21, 1863. 2 pamph. 8vo. Boston. 1863.

American Oriental Society.

Journal. Eighth Volume. No. 1. 8vo. New Haven. 1864.

Proceedings at Boston and Cambridge, May 20th and 21st, 1863. 8vo. New Haven. 1863.

Editors of American Journal of Science and Arts.

Journal. N. S. Vol. XXXVI. - XXXVIII. No. 112. 8vo. New Haven. 1863 - 64.

Lyceum of Natural History of New York.

Charter, Constitution, and By-Laws of the Lyceum, ... with a List of the Members, etc. 1864. 8vo pamph. New York.

Mercantile Library Association of the City of New York.

Forty-Second Annual Report of the Board of Directors, May, 1863. 8vo pamph. New York.

Academy of Natural Sciences of Philadelphia.

Journal. N. S. Vol. V. Part 4. 4to. Philadelphia. 1863.

Proceedings. 1863. No. 3 - 7. 8vo. Philadelphia. 1863.

American Philosophical Society.

Proceedings. Vol. IX. No. 69, 70. 8vo. Philadelphia. 1863.

Philadelphia College of Pharmacy.

American Journal of Pharmacy. Ser. 3. Vol. XI., XII. No. 1. 8vo. Philadelphia. 1863 - 64.

Smithsonian Institution.

Annual Report of the Board of Regents of the Smithsonian Institution for the Year 1862. 8vo vol. Washington. 1863.

Library of Congress.

Catalogue of the Library of Congress. Printed by order of Congress. 8vo vol. Washington. 1861.

Catalogue of Additions made to the Library of Congress from December 1, 1862, to December 1, 1863. 8vo vol. Washington. 1863.

American Association for the Advancement of Science.

Third Meeting, held at Charleston, S. C., March, 1850. 8vo vol.
Charleston, S. C. 1850.

Young Men's Mercantile Library Association of Cincinnati.

Twenty-Eighth and Twenty-Ninth Annual Report of the Board
of Directors for the Years 1862, 1863. 2 pamph. 8vo. Cincinnati.
1863 - 64.

California Academy of Natural Sciences.

Proceedings. Vol. III. pp. 1-112. 8vo. San Francisco.
1863.

Literary and Historical Society of Quebec.

Transactions. Vol. IV. Part 1-3. Vol. V. Part 1. 8vo.
Quebec. 1843 - 63.

Report of the Council for the Year 1862. 8vo pamph. Quebec.
1863.

The Gold Fields of Canada ; a Paper read before the Literary
and Historical Society of Quebec, November 18, 1863. By Rev.
James Douglas. 8vo pamph. Quebec. 1863.

Geological Survey of Canada. Report of Progress from its Com-
mencement to 1863 ; illustrated by 498 Wood-Cuts in the Text, and
accompanied by an Atlas of Maps and Sections. Royal 8vo vol.
Montreal. 1863.

Royal Society of London.

Philosophical Transactions. Vol. 151, Vol. 152, Part 1. 4to.
London. 1862 - 63.

Proceedings. Vol. XII., Vol. XIII. No. 58, 59. 8vo. London.
1863.

List of Fellows, etc. December 1, 1862. 4to pamph. Lon-
don.

Astronomical and Magnetical and Meteorological Observations
made at the Royal Observatory, Greenwich, in the Year 1861. 4to
vol. London. 1863.

The Bakerian Lecture. On the Total Solar Eclipse of July 18,
1860, observed at Rivabellosa, near Miranda de Ebro, in Spain.
By Warren De La Rue, Esq., Ph. D., F. R. S., etc. [From
Philos. Trans. Part 1. 1862.] 4to. London. 1862.

Linnean Society of London.

Transactions. Vol. XXIII., Vol. XXIV. Part 1. 4to. Lon-
don. 1862 - 63.

Journal of the Proceedings. Zoölogy, Vol. VI., Vol. VII. No. 25, 26. Botany, Vol. VI., Vol. VII. No. 25, 26. 8vo. London. 1862 - 63.

List of the Linnean Society, 1861 - 62. 8vo. London.

Address of Thomas Bell, Esq., F. R. S., etc. The President. . . . Friday, May 24, 1861. 8vo. London. 1861.

Address of George Bentham, Esq., F. R. S., etc. The President. . . . Saturday, May 24, 1862. 8vo. London. 1862.

Zoölogical Society of London.

Transactions. Vol. IV., Vol. V. Part 1, 2. 4to. London. 1862 - 63.

Proceedings for the Years 1861, 1862. 8vo. London. 1861 - 62.
Statistical Society of London.

Journal. Vol. XXVI. 8vo. London. 1863.

Geological Society of London.

Quarterly Journal. Vol. XIX. 8vo. London. 1863.

Royal Horticultural Society of London.

Proceedings. Vol. III., Vol. IV. No. 1, 2. 8vo. London. 1863 - 64.

Royal Astronomical Society.

Memoirs. Vol. XXXI. 1861 - 62. 4to. London. 1863.

British Association for the Advancement of Science.

Report of the Thirty-Second Meeting, held at Cambridge in October, 1862. 8vo vol. London. 1863.

Royal Institution of Great Britain.

Proceedings. Vol. IV. Part 1, 2. No. 37, 38. 8vo. London. 1863.

List of the Members, Officers, and Professors. 1863. 8vo pamph. London.

Society of Arts, Manufactures, and Commerce.

Journal of the Society of Arts and of the Institutions in Union. Vol. XI. No. 545 - 571, 575. 8vo. London. 1863.

Chemical Society of London.

Journal. Ser. 2. Vol. I. 8vo. London. 1863.

British Government.

Extension of the Triangulation of the Ordnance Survey into France and Belgium with the Measurement of an Arc of Parallel in Latitude 52° N. from Valentia in Ireland to Mount Kemmel in Belgium. . . . By Colonel Sir Henry James, R. E., F. R. S., etc., Director of the Ordnance Survey. 4to vol. London. 1863.

Tyneside Naturalists' Field-Club.

Transactions. Vol. VI. Part 1. 8vo. Newcastle-upon-Tyne. 1863.

A Synopsis of the Geology of Durham and Part of Northumberland, by Richard House and J. W. Kirby. 8vo pamph. Newcastle-upon-Tyne. 1863.

Radcliffe Trustees.

Astronomical and Meteorological Observations made at the Radcliffe Observatory, Oxford, in the Year 1861. Under the Superintendence of the Rev. Robert Main, M. A., Radcliffe Observer. Vol. XXXI. 8vo. Oxford. 1861.

Literary and Philosophical Society of Liverpool.

Proceedings during the Fifty-Second Session, 1862 – 63. No. XVII. 8vo vol. Liverpool. 1863.

Royal Dublin Society.

Journal. Vol. IV. No. 29, 30. 8vo. Dublin. 1863.

Geological Society of Dublin.

Journal. Vol. IX. Part 2. Vol. X. Part 1. 1861 – 63. 8vo. Dublin.

Government of India.

Palæontologia Indica. Ser. II. Part 3 – 6. Ser. III. Part 1. 4to. Calcutta. 1862 – 63.

Annual Report of the Geological Survey of India and of the Museum of Geology, for the Year 1862 – 63. 8vo pamph. Calcutta. 1863.

Académie des Sciences de l'Institut Impériale de France.

Comptes Rendus. Vol. LVI., LVII., LVIII. No. 1 – 18. 4to. Paris. 1863 – 64.

Société Impériale Zoologique d'Acclimatation.

Bulletin. Vol. X. Série 2. Vol. I. No. 1 – 3. 8vo. Paris. 1863 – 64.

Société de Géographie.

Bulletin. Sér. 5. Vol. V. 8vo. Paris. 1863.

Académie Impériale des Sciences, etc. de Dijon.

Mémoires. Sér. 2. Vol. X. 1862. 8vo. Dijon. 1863.

Académie Impériale des Sciences, Belles-Lettres, et Arts de Lyon.

Mémoires. Classe des Lettres. N. S. Vol. IX., X., XI. Classe des Sciences. Vol. X., XI., XII. 8vo. Paris and Lyons. 1859 – 62.

Königl. Preussische Akademie der Wissenschaften, Berlin.

Abhandlungen. 1862. 4to. Berlin. 1863.

Monatsberichte. 1862. 8vo. Berlin. 1863.

Königl. Universitäts Sternwarte, Bonn.

Atlas des Nördlichen Gestirnten Himmels für den Anfang des Jahres 1855, unter Mitwirkung der Herren Dr. E. Schönfeld und Prof. Dr. Krueger. Entworfen und in Namen Sternwarte herausgegeben von dem Director derselben, Dr. F. W. Argelander. Long 4to. Bonn. 1863.

Universitas Frid. Guil. Rhenana, Bonnæ.

Academical Dissertations and Indexes. Bonn. 1862.

Naturforschender Verein in Brünn.

Verhandlungen. Vol. I. 1862. 8vo. Brünn. 1863.

Naturforschende Gesellschaft in Danzig.

Schriften. N. S. Vol. I. Part 1. 4to. Dantzie. 1863.

Verein für Erdkunde und verwandte Wissenschaften zu Darmstadt.

Notizblatt. Serie 3. No. 13 - 24. 8vo pamph. Darmstadt. 1863.

Königliche Blindenanstalt zu Dresden.

Jahresbericht. 1862. 8vo pamph. Dresden.

Naturforschende Gesellschaft in Emden.

Jahresbericht. 1862. 8vo. Emden. 1863.

Kleine Schriften. No. X. 4to. Emden. 1862.

Zoologische Gesellschaft, Frankfurt a. M.

Zoologische Garten. Vol. IV., V., No. 1. 8vo. Frankfort-on-the-Main. 1863 - 64.

Naturforschende Gesellschaft zu Freiburg im Briesgau.

Berichte über die Verhandlungen. Vol. III. Part 1. 8vo. Freiburg i. B. 1863.

Oberhessische Gesellschaft für Natur und Heilkunde, Geissen.

Zehnter Bericht. 8vo. Geissen. 1863.

Oberlausitzische Gesellschaft zu Görlitz.

Neues Lausitzisches Magazin. Vol. XL. 8vo. Görlitz. 1863.

Königl. Gesellschaft der Wissenschaften zu Göttingen.

Nachrichten von der Georg-Augusts-Universität und der Königl. Gesellschaft der Wissenschaften vom Jahre 1862. 16mo vol. Göttingen.

Naturforschende Gesellschaft zu Halle.

Abhandlungen. Vol. VII. Part 2. 4to. Halle. 1863.

Königl. Physikalisch-Oekonomische Gesellschaft zu Königsberg.

Schriften. Vol. III. Part 1, 2. 4to. Königsberg. 1863.

*Königl. Sächsische Gesellschaft der Wissenschaften, Leipzig.*Abhandlungen. Math.-Phys. Classe, Vol. VI. pp. 501–570 :
Philol.-Histor. Classe, Vol. X. pp. 348–496. 8vo. Leipsic.
1863.Berichte über die Verhandlungen. Vol. XIV. 8vo. Leipsic.
1862.*Naturwissenschaftlicher Verein für das Fürstenthum Lüneburg.*

Jahresbericht. 1862–63. 8vo. Lüneburg. 1863.

Société des Sciences Naturelles du Grand-Duché de Luxembourg.

Vol. V. Années 1857–62. 8vo. Luxembourg. 1862.

*Königl. Bayerische Akademie der Wissenschaften, München.*Abhandlungen. Math.-Phys. Classe. Vol. IX. Part 3. Philos.-
Philolog. Classe. Vol. IX. Part 3. 4to. Munich. 1863.Sitzungsberichte. 1862. Vol. II. Part 2–4. 1863. Vol. I.
Part 1–4. Vol. II. Part 1. 8vo. Munich. 1862–63.Denkrede auf Joh. Andreas Wagner. Gehalten von Dr. Carl
Fried. Phil. von Martius. 4to pamph. Munich. 1862.Rede in der Öffentlichen Sitzung der Akademie der Wissen-
schaften am 28 März, 1863, zur Feier ihres Einhundert und Vier-
ten Stiftungstages, gehalten von J. F. von Liebig. 4to pamph.
Munich. 1863.Rede gehalten von dem Königl. Universitäts-Professor Dr. Cor-
nelius. 4to pamph. Munich. 1862.*Naturhistorische Gesellschaft zu Nürnberg.*

Abhandlungen. Vol. I., II. 8vo. Nuremberg. 1858–61.

*Offenbacher Verein für Naturkunde, Offenbach.*Der Dr. Joh. Christ Senckenbergischen Stiftung widmet zu ihrer
Sæcularfeier am 18 August, 1863, diese Denkschriften der Offen-
bacher Verein für Naturkunde.Der Gorilla, mit Berücksichtigung des Unterschiedes zwischen
Menschen und Affen, und der neueren Umwandlungstheorie der
Arten, dargestellt von Dr. med. R. Meyer.

Mineralogisch-chemische Notizen, von Dr. Theodor Petersen.

Geschichte zweier Kaiserschnitte, ... von Dr. med. Heinrich
Walter.Neue Semperviven, von C. B. Lehmann in Offenbach a. M., und
Hofgartendirector Schnittpahn in Darmstadt. 4to pamph. Offen-
bach.

K. K. Sternwarte zu Prag.

Magnetische und Meteorologische Beobachtungen. Vol. XXIII.
4to. Prague. 1863.

Zoologisch-Mineralogische Verein in Regensburg.

Correspondenz-Blatt. Vol. XVII. 16mo. Ratisbon. 1862.

Entomologischer Verein zu Stettin.

Entomologische Zeitung. Vol. XXIV. 8vo. Stettin. 1863.

Kaiserliche Akademie der Wissenschaften, Wien.

Denkschriften. Math.-Naturw. Classe. Vol. XXI. 4to. Vienna. 1863.

Sitzungsberichte. Math.-Naturw. Classe. Vol. XLVI., Vol. XLVII. Part 1, No. 1-3; Part 2, No. 1-4. 1864. No. 1. Philos.-Histor. Classe. Vol. XL., Vol. XLI. No. 1-3, Vol. XLII. No. 3. 8vo. Vienna. 1862-63.

Register der Sitz. Philos.-Histor. Classe. Vol. XXXI.-XL. 8vo. Vienna. 1863.

Almanach der Kaiserl. Akademie. Vol. XIII. 16mo. Vienna. 1862.

K. K. Zoologisch-Botanische Gesellschaft, Wien.

Verhandlungen. Vol. XII. 1862. 8vo. Vienna. 1862.

Personen-, Orts- und Sach-Register der Zweiter Fünfjährigen Reihe 1856-60 der Sitzungsberichte und Abhandlungen. 8vo vol. Vienna. 1861.

K. K. Geographische Gesellschaft, Wien.

Mittheilungen. Vol. V. 8vo. Vienna. 1861.

K. K. Geologische Reichsanstalt, Wien.

Jahrbuch. Vol. XIII. No. 1, 2. 8vo. Vienna. 1863.

General Register. Vol. I.-X. 1850-59. 8vo vol. Vienna. 1863.

Naturforschende Gesellschaft in Bern.

Mittheilungen. 1862. 8vo vol. Berne. 1862.

Société Suisse des Sciences Naturelles.

Compte Rendu de la 45^e Session réunie a Lausanne les 20, 21, et 22 Août, 1861. 8vo vol. Lausanne. 1861.

Schweizerische Naturforschende Gesellschaft.

Verhandlungen bei ihrer Versammlung zu Luzern, den 23, 24 und 25 September, 1862. 46. Versammlung. 8vo vol. Lucerne.

Académie Royale des Sciences, &c. de Belgique, Bruxelles.

Mémoires. Serie 2. Vol. XIII., XIV. 4to. Brussels. 1862.

Mémoires Couronnés. Coll. in 8vo. Vol. XIII., XIV. 8vo. Brussels. 1862.

Annuaire. Vol. XXIX. 18mo. Brussels. 1863.

Alexanders Geesten van Jacob van Maerlant. Vol. 10. Royal 8vo. Brussels. 1862.

Bibliothèque de M. Le Baron de Stassart leguée a l'Académie Royal de Belgique. 8vo vol. Brussels. 1863.

Observatoire Royale de Bruxelles.

Annales. Vol. XV. 4to. Brussels. 1862.

Hollandsche Maatschappij der Wetenschappen te Haarlem.

Natuurkundige Verhandelingen. Ser. 2. Vol. XVII., XIX. Part 1. 4to. Haarlem. 1862.

Koninklijk Nederlandsch Meteorologisch Instituut.

Meteorologische Waarnemingen in Nederland en Zijne Bezittingen en Afwijkingen van Temperatuur en Barometerstand op vele Plaatzten in Europa, 1862. Long 4to vol. Utrecht. 1863.

Société Impériale des Naturalistes de Moscou.

Vol. XXXVI. No. 1, 2. 8vo. Moscow. 1863.

Académie Impériale des Sciences de St. Petersbourg.

Mémoires. Sér. 7. Vol. V. No. 4; Vol. VI. No. 7. 4to. St. Petersburg. 1862 - 63.

Bulletin. Vol. IV. No. 7 - 9; Vol. V. No. 1, 2. 4to. St. Petersburg. 1862.

Positiones Mediae Stellarum Fixarum in Zonis Regiomontanis a Besselio inter $+15^{\circ}$ et $+45^{\circ}$ Declinationis Observatarum. 4to vol. St. Petersburg. 1863.

Jahresbericht am 14. Juni, 1863, dem Comite der Nicolai Hauptsternwarte, abgestattet vom Director der Sternwarte (O. Struve). Aus dem Russischen übersetzt. 12mo pamph. St. Petersburg. 1863.

Kongel. Danske Videnskabernes Selskab, Kjöbenhavn.

Skrifter. Ser. 5. Naturv. og Math. Afd. Vol. V. Part 2. 4to. Copenhagen. 1861.

Oversigt. Förhandlingar. 1861. 8vo vol. Copenhagen. 1861.

Kongel. Norske Frederiks Universitet, Christiania.

Aarsberetning for 1861. 16mo pamph. Christiania. 1862.

Index Scholarum. 1863. 2 pamph. 4to. Christiania.

Norske Vægtlodder fra Fjortende Aarhundrede. Beskrevne af C. A. Holmboe, Prof. LL. OO. Universitetsprogram for Andet Halvaar 1863. 4to pamph. Christiania. 1863.

VOL. VI.

36

Det Kongel. Fred. Universitet Halvhundredaars-Fest, Sept. 1861. 8vo pamph. Christiania. 1862.

Nyt Magazin for Naturvidenskaberne. Udgives af den physiographiske Forening i Christiania ved M. Sars og Th. Kjerulf. Vol. XII. Part 1-3. 8vo. Christiania. 1863.

Lappiske Sprogprover. En Samling af lappiske Eventur. Ord-sprog, og Gaader, med Ordbog, af J. A. Früs. 8vo vol. Christiania. 1856.

Muttom Salmak, mak loek samas jorggaluvvum darro-ja suomagiel salbmagirjin. 16mo pamph. Christiania. 1861.

Kongl. Svenska Vetenskaps Akademien.

Ofversigt af Kongl. Vetenskaps Akademien Forhandlingar. Vol. XVII. - XIX. 8vo. Stockholm. 1861 - 63.

Kongl. Vetenskaps Akademien, May 1861, 1862, 1863. 3 pamphlets, 8vo. Stockholm.

Kongl. Svenska Fregatten Eugenies Resa omkring Jorden. Vetenskapliga Jakttagelser. Part 8-11. 4to. Stockholm. 1861.

Jakttagelser och anteckningar till Finnmarkens och Spetsbergens Däggdjursfauna. Af A. J. Malmgren. 8vo pamph. Stockholm.

Anteckningar till Spetsbergens Fogel-Fauna. Af A. J. Malmgren. 8vo pamph. Stockholm.

Crustacea decapoda podophthalma marina Sueciæ, interpositis speciebus Norvegicis aliisque vicinis, enumerat A. Goës. 8vo pamph. Stockholm.

Regia Societas Scientiarum Upsaliensis.

Nova Acta. Ser. 3. Vol. IV. Part 2. 4to. Upsal. 1863.

Upsala Universitets Årsskrift. 1862. 8vo. Upsal. 1863.

Societa Reale di Napoli.

Rendiconto dell' Accademia delle Scienze Fisiche e Matematiche. Vol. I. 1862. Vol. II. Part 1-7. 1863. 4to. Naples. 1862 - 63.

Reale Accademia delle Scienze di Torino.

Memorie. Ser. 2. Vol. XX. 4to. Turin. 1863.

Accademia Real das Sciencias de Lisboa.

Memorias. Classe de Sciencias Moraes, Polit., e Bellas Lettras. N. S. Vol. II. Part 2. Classe de Sciencias Math. Phys. e Nat. N. S. Vol. III. Part 1. 4to. Lisbon. 1863.

Historia e Memorias. Classe de Sciencias Moraes, Polit. e Bellas Lettras. N. S. Vol. III. Part 1. 4to. Lisbon. 1863.

Portugaliae Monumenta Historica. Leges et Consuetudines. Vol. I. Part 3. Folio. Lisbon. 1863.

Lendas da India por Gaspar Correa publicadas de Ordem da Classe de Sciencias Moraes, etc., e sob a Direcção de Rodrigo Jose de Lima Felner. Vol. III. Part 1, 2. 4to. Lisbon. 1862 - 63.

Corpo Diplomatico Portuguez. Vol. I. 4to. Lisbon. 1862.

Natuurkundige Vereeniging in Nederlandsch Indie, Batavia.

Natuurkundig Tijdschrift. Vol. XXIV. Serie 5. Vol. IV. Part 5, 6. Vol. XXV. Serie 5. Vol. V. Part 1 - 6. Vol. XXVI. Serie 6. Vol. I. Part 1, 2. 8vo. Batavia. 1862 - 63.
L. Agassiz.

Annual Report of the Trustees of the Museum of Comparative Zoölogy, together with the Report of the Director, 1862. 8vo pamphlet. Boston. 1863.

Charles Beck.

The Manuscripts of the Satyricon of Petronius Arbiter, described and collated by Charles Beck. 4to vol. Cambridge. 1863.

Report of the Trustees of the Subscription-Fund for the Benefit of the Cambridge Volunteers. 8vo pamph. Cambridge. 1863.

George Ticknor.

History of Spanish Literature. By George Ticknor. In Three Volumes. Third American Edition, corrected and enlarged. 12mo. Boston. 1863.

Life of William Hickling Prescott. By George Ticknor. 4to vol. Boston. 1864.

Charles Folsom.

Catalogue of the Officers and Students of Harvard University for the Academical Year 1863 - 64. First Term. 12mo pamph. Cambridge. 1863.

O. P. Hubbard.

Catalogue of the Officers and Students of Dartmouth College for the Academical Year 1863 - 4. 8vo pamph. Hanover, N. H. 1863.

Professor William D. Whitney.

On the Views of Biot and Weber, respecting the Relations of the Hindu and Chinese Systems of Asterisms; with an Addition on Müller's Views respecting the same Subject. [From Jour. Am. Or. Soc. Vol. VIII. 1864.] 8vo. New Haven. 1863.

Henry Bryant, M. D.

Traité de la Turbine-Tourneyson. . . . Par Dobronravoff, Colo-

nel du génie et Professeur de l'Institut des voies de communication.
Traduit du Russe, par l'Auteur. 8vo vol. St. Petersburg. 1850.
Prof. Joseph Winlock, U. S. N.

American Ephemeris and Nautical Almanac for the Years 1855 –
64. 10 Vols. Royal 8vo. Washington. 1852 – 62.
John Dean, M. D.

The Gray Substance of the Medulla Oblongata and Trapezium.
Memoir, with Photographs. [Smithsonian Contributions to Knowledge.] 2 Parts. 4to. Washington. 1864.
William F. Poole.

List of Books added to the Library of the Boston Athenæum
from December 1, 1862 to December 1, 1863. 2 pamph. 8vo.
Boston. 1863.
Charles C. Jewett.

Eleventh Annual Report of the Trustees of the Public Library.
8vo pamph. Boston. 1863.
Isaac Lea, LL. D.

Observations on the Genus *Unio*, together with Descriptions of
New Species, their Soft Parts, and Embryonic Forms in the Family
Unionidæ. Vol. 10. 4to pamph. Philadelphia.
Colonel Samuel Swett.

Original Planning and Construction of Bunker Hill Monument,
with Engravings. 8vo pamph. Albany. 1863.
Edward Jarvis, M. D.

Memorial of the Boston Sanitary Association to the Legislature
of Massachusetts, asking for the Establishment of a Board of Health
and of Vital Statistics. 8vo pamph. Boston. 1861.
Hon. Charles G. Loring.

England's Liability for Indemnity. Remarks on the Letter
"Historicus," dated November 4, 1863; printed in the London
"Times," November 7, and reprinted in the "Boston Daily Adver-
tiser," November 25. 8vo pamph. Boston. 1864.
James Hall.

Sixteenth Annual Report of the Regents of the University of the
State of New York, on the Condition of the State Cabinet of Natu-
ral History. . . . Transmitted to the Legislature, April 15, 1863.
8vo pamph. Albany. 1863.
Hon. Charles Sumner.

Letter of the Secretary of War, communicating, in answer to a

Resolution of the Senate, a Copy of the Report of Major D. Ferguson on the Country, its Resources, and the Route between Tucson and Lobos Bay. 8vo pamph. Washington. 1863.

Report of the Superintendent of the Coast Survey, showing the Progress of the Survey during the Year 1861. 4to vol. Washington. 1862.

Expedition of Captain Fisk to the Rocky Mountains. Letter from the Secretary of War in answer to a Resolution of the House of February 26, transmitting Report of Captain Fisk of his late Expedition to the Rocky Mountains and Idaho. 8vo pamph. Washington. 1864.

George W. Clinton.

Preliminary List of Plants of Buffalo and its Vicinity. 8vo pamph. Buffalo. 1864.

J. W. Dawson, LL. D., F. R. S., etc.

Air-Breathers of the Coal Period; a Descriptive Account of the Remains of Land Animals, found in the Coal Formation of Nova Scotia. 8vo pamph. Montreal. 1863.

Sir William Logan.

Geological Survey of Canada. Report of Progress from its Commencement to 1863; illustrated by 498 Wood Cuts in the Text, and accompanied by an Atlas of Maps and Sections. 8vo vol. Montreal. 1862.

Rev. Samuel Haughton, M. A., F. R. S., etc.

Experimental Researches on the Granites of Ireland. Part 3. On the Granites of Donegal. 8vo pamph. London. 1862.

On the Rainfall and Evaporation in Dublin in the Year 1860. 8vo pamph. Dublin. 1862.

On the Direction and Force of the Wind at Leopold Harbor. 8vo pamph. Dublin. 1863.

On the Form of the Cells made by various Wasps, and by the Honey Bee; with an Appendix on the Origin of Species. 8vo pamph. Dublin. 1863.

Essay on Comparative Petrology. By M. J. Durocher. Translated from the "Annales des Mines." Vol. XI. 1857. By Rev. Samuel Haughton. 8vo pamph. Dublin. 1859.

On the Phenomena of Diabetes Mellitus. 8vo pamph. Dublin. 1863.

On the Rainfall and Evaporation of St. Helena. By John Haughton, Esq., Lieut. R. R. A. 8vo pamph. Dublin. 1862.

Editors.

The Reader. A Review of Literature, Science, and Art. Vol. III. No. 63, 65-68. 8vo. London. 1864.

Carl Friedr. Phil. von Martius.

Glossaria Linguarum Brasiliensium. Glossarios de diversas Lin-
goas e Dialectos que fallao os Indios no Imperio do Brazil. Wörter-
sammlung brasilianischer Sprachen. Beiträge zur Ethnographie und
Sprachenkunde Brasiliens. II. Zur Sprachenkunde. 8vo vol. Er-
langen. 1863.

Von dem Rechtszustande unter den Ureinwohnern Brasiliens.
Eine Abhandlung von Dr. C. F. Ph. von Martius. 4to pamph.
Munich. 1832.

Die Fieber-Rinde, der China-Baum, sein Vorkommen und seine
Cultur; von Dr. C. F. Ph. von Martius. (Besonderer Abdruck aus
Buchner's "Neuem Repertorium für Pharmacie." Bd. XII. S. 337.)
8vo pamph.

Dr. L. F. von Schlechtendal.

Linnæa. Ein Journal für die Botanik in ihrem ganzen Um-
fange. Vol. XXXI. Part 2-6; Vol. XXXII. Part 1, 2. 8vo.
Halle. 1861-63.

L. W. Schaufuss.

Dictator Schaum. Ein Offner Brief an alle Entomologen.
Zweite unveränderte Auflage. 8vo pamph. Dresden. 1863.

A. Quetelet.

Annuaire de l'Observatoire Royal de Bruxelles. 1863. Vol. 30.
18mo. Brussels. 1862.

Difference des Temps entre Bruxelles et Vienne pour les Époques
Critiques des Plantes et des Animaux, par M. Ad. Quetelet. 8vo
pamph. Brussels. 1862.

Sur les Nebeleuses. Sur l'Hygrométrie. Sur les Variations
Périodiques de l'Atmosphère, etc. 8vo pamph. Brussels. 1862.

M. J. Desnoyers.

Note sur des Indices Matériels de la Coexistence de l'Homme
avec l'Elephas Meridionalis dans un Terrain des Environs de Char-
tres, plu ancien que les Terrains de Transport quaternaries des Val-
lées de la Somme et de la Seine. (Extr. des Comptes Rendus de
l'Académie des Sciences. Seance du 8. Juin, 1863.) 4to pamph.
Paris. 1863.

Réponse à des Objections faites au Sujet de Stries et d'Incisions

constatées sur des Ossements de Mammifères Fossiles des Environs de Chartres. (Extr. des Compt. Rend. de l'Académie des Sciences. T. 56. Seance du 29. Juin, 1863.) 4to pamph. Paris. 1863.

Henri de Saussure.

Études sur le Métamorphisme des Roches, par M. Delesse. Tiré de la Bibliothèque Universelle et Revue Suisse [Archives des Sciences Phys. et Nat.] livr. d'Avr. 1863. T. XVI. 8vo pamph.

Ephemeriden der seit 1845 entdeckten Planeten für das Jahr 1864. Supplement zu dem Berliner Jahrbuch für 1866. 8vo vol. Berlin. 1864.

T. C. Winkler.

Musée Teyler. Catalogue Systématique de la Collection Paléontologique. 1st Part. 8vo pamph. Harlem. 1863.

Prof. C. Hansteen.

Magnetiske Jagttagelser paa Island og Spitsbergen. 8vo pamph. Christiania.

Resultate Magnetischer, Astronomischer, und Meteorologischer Beobachtungen auf einer Reise nach dem Oestlichen Sibirien, in den Jahren 1828–30. 4to vol. Christiania. 1863.

Five hundred and thirty-seventh Meeting.

August 10, 1864. — STATUTE MEETING.

The PRESIDENT in the chair.

The President read letters from Mr. R. W. Emerson and Dr. J. B. Upham, in acknowledgment of their election into the Academy.

The following paper was presented by the President : —

Synopsis of North American Gaurineæ. By J. T. ROTHROCK.

IN an examination of *Gaura coccinea*, I noticed an appendage at the base of each filament, and an indusium surrounding the stigma. Both these characters appearing to us at the time not to have been observed before, at the suggestion of Professor Gray I undertook to see how far they could be turned to account in the classification of

Gaura and its near allies. While so engaged, I found that Linnæus had noticed these appendages at least as early as in the fifth edition of his *Genera Plantarum*.^{*} It is probable that they were mentioned in his paper in the *Acta Holmiensia*, in which he established the genus. With the exception of Jussieu,[†] subsequent authors seem to have lost sight of them.

These appendages are present in all the species of *Gaura* (though in *G. parviflora* reduced to a minimum); but are wanting in *Stenosi-phon* and the *G. heterandra* of Torrey. On account of this and other differences, I have been led to propose the latter as the type of a new genus (*Heterogaura*).

The nearest analogue to these appendages with which I am acquainted will be found in many of the *Zygophyllaceæ*, — *Larrea*, for example, — where they are much more developed, and are almost as long as the filament. From their position, it may be inferred that they do not represent an additional set of stamens, but are part of the filament to which they are attached. If the hypothesis of chorisis be admitted, they may be regarded as fine examples of it, either of *vertical* chorisis, if their position before the filament be taken as normal; or of *collateral*, if (as the notch at their apex sometimes may indicate) they be considered as homologous with a pair of stipules. I have never been able to find such appendages on the inside of any broad-based filaments.

Though the presence or absence of the appendages is a good generic character in *Gaurineæ*, they are much too variable to serve for limiting species, except in *G. parviflora*, where they are reduced to mere papillæ, and in *G. Drummondii*, which has those of the filaments opposite the petals decidedly shorter than the others.

As to the indusium or ring surrounding the base of the stigma, in the same genus, I found that this also had been noticed before, or at least represented. That is, it had been figured in Payer's *Organogenie Végétale* (tab. 150, f. 34–36), in young flower-buds of *G. bien-nis*; but there is no reference to the subject in the letter-press.

It is clearly of the same nature as the indusium in *Ericaceæ*, noticed by Robert Brown, in which, as Mr. Bennett remarks, the likeness to

* "Glandula nectarifera conica intra basin singuli." — Linn. *Gen. Plant.* Ed. 5 (1754).

† "Glandulas 8 in *G. bienni* memorat Linnæus summo calici adnatas." — Juss. *Gen. Plant.*

the more strongly developed one of *Goodenovia* is too obvious to escape attention.* In several species of *Gaura*, the whole structure is strikingly like that of *Epigaea repens*, i. e. with the four (in *Epigaea* five) lobes of a manifest indusium adnate to the under side of each projecting stigma. Sometimes, as in *G. villosa* and *G. tripetala*, the lobes of the indusium are confluent with or firmly adherent throughout to their stigmas. In others, as *G. Lindheimeri*, the lobes are free at the summit, or soon become so, or may easily be separated down to their base. In *G. coccinea*, the annular or crateriform indusium is quite entire and mainly free; in *G. longiflora*, nearly so; in *G. sinuata*, slightly four-lobed. In *G. parviflora* alone, the stigmas are scarcely exerted beyond the indusium.

Probably the indusium may in some instances furnish good characters; but they are difficult to fix in dried specimens, and vary somewhat during and after anthesis. *G. Lindheimeri* is the only species of which I can at this season examine the live plant.

In *Stenosiphon*, the indusium is peltate and nearly entire, but (in the dried specimens) more or less plicate or intruded between the stigmas, so as partly to enwrap their bases. In *Gaura heterandra*, Torr., there appears to be no indusium: at least, if there is anything answering to such an organ, it is so completely confluent with the entire and disk-shaped proper stigma that it is not at all discernible. This, added to the total want of appendages on the base of the filament, as already remarked, strengthens the conviction that this anomalous plant is a new generic type, much more distinct from *Gaura*, indeed, than *Stenosiphon* is. The habit of the plant, which is rather that of *Clarkia*, and the equally spreading instead of the declined stamens, confirm this view.

The three genera of the group (*Schizocarya*, Spach, and apparently his *Gauridium*, not differing from *Gaura*) may be contrasted as follows.

Subtribus GAURINEÆ, Spach.

Calyx tubo supra ovarium producto, post anthesin deciduo. Stamina duplo petalorum numero. Ovarium (4-3-, rarissime 6-) ovulatum. Fructus nucamentaceus, abortu 1-4-spermus.

1. GAURA, L. Calycis tubus obconicus vel elongato-clavatus.

* *Plantæ Javanicæ Rariores*, 1. p. 86.

Stamina conformia, declinata: filamenta basi intus appendice squamæ-formi aucta: antheræ sæpissime lineari-oblongæ. Stigma quadripartitum, indusio vel adnato vel fere libero cinctum. Ovarium 4- (quandoque 3-) locale, loculis 1- (in alternis raro 2-) ovulatis. Fructus dissepimentis evanidis unilocularis.

2. *STENOSIPHON*, Spach. Calycis tubus filiformis. Stamina conformia, declinata: antheræ ovaes, medio affixæ; filamenta tenuissima, exappendiculata. Stigma quadripartitum, indusio peltato basi loborum adnato (inter lobos pl. m. involuto) suffultum. Ovarium (dissepimentis nullis) uniloculare, 4-ovulatum. Fructus abortu monospermus.

3. *HETEROGAURA*, nov. gen. Calycis tubus brevis, obconicus. Stamina erecta, 4 petalis alterna fertilia antheris ovato-cordatis; 4 petalis opposita fere ananthera breviora: filamenta exappendiculata. Stigma disciforme, integrum: indusium nullum. Ovarium 4-locale, loculis uniovulatis. Fructus obovato-gibbosus, 2-4-locularis, abortu mono- (vel di?) spermus. Vide infra.

Respecting *Stenosiphon* (still of a single species), I have nothing to add. The species of *Gaura* I have endeavored to define mainly by the flower and fruit. As to the latter, it must be remarked that only the mature or nearly mature fruit is of much account in distinguishing the species; and in the following characters the ripe fruit is to be understood as in view, except where it is otherwise specified. The young or forming fruit is quite too variable.

The characters of our species derived from the fruit may be briefly presented in the following tabular key.

Fructus sessilis vel subsessilis (i. e. flores spicata):

usque ad basim tetraqueter, quandoque triqueter,

pyramidatus, glaber, angulis acutissimis, faciebus in sicco plus minus cor-
rugatis. G. TRIPETALA, G. SUFFULTA.

oblongus, glaber, lævis, angulis acutissimis. G. LINDHEIMERI.

oblongus seu ovatus, pubens vel puberulus,
acutissime angulatus, utrinque acutus. G. ANGUSTIFOLIA.

obtusiuscule angulatus, subcanescens, parvus. G. LONGIFLORA.

obtusiuscule angulatus, velutino pubescens (3-4 lin-longus). G. BIENNIS.

basi teretiuscula sensim brevè attenuatus, superne obtusangulus. G. PARVIFLORA.

infra medium in collum teres subito contractus, superne pyramidatus,
canescens, collo crasso. G. DRUMMONDII.

glaber, collo tenui. G. COCCINEA.

Fructus manifeste in pedicellum clavato-attenuatus vel contractus :

- parvus, parte seminifera ($1\frac{1}{2}$ lin.) ovato-pyramidata obtusissima. G. FILIPES.
 elongatus, cum pedicello semipollicaris, apice sæpius pl. m. attenuatus,
 tetraqueter, angulis acutis. G. VILLOSA.
 fusiformis, obtusangulus (maturus vero hand visus),
 cano-puberulus, costis inter angulos validis percursus. G. MACROCARPA.
 glaber, costis angulis alternantibus obsoletis. G. SINUATA.

The following synopsis is restricted to the North American species of *Gaura*. I am unable to complete the monograph by adding the few peculiar to Mexico, no specimens of these being accessible to me.

GAURÆ BOREALI-AMERICANÆ.

§ 1. *Antheræ lineares seu lineari-oblongæ (in G. angustifolia tantum brevi-oblongæ), supra basim affixæ; appendices filamentorum squamæformes vel subulatæ: stigmata ultra indusium exserta.*

* *Fructus sessilis vel subsessilis.*

+ *Fructus tetra- (quandoque tri-) queter, vix ac ne vix attenuatus. — Biennes vel annuæ (nunc perennes?), caulibus elongatis virgatis, bracteis caducis.*

++ *Rhachis fructu delapso hand dentata vel squarrosa, cicatricibus parvis. Fructus ad latera lævis. Appendices staminum parvæ vel parvulæ.*

1. G. LINDHEIMERI, Engelm. & Gray (Pl. Lindh., 1. p. 9): strigoso-pubescent vel hirsuta, grandiflora; calyce in albastro crinito-piloso, segmentis tubo quadruplo longioribus; stylo basi piloso; fructu oblongo acutato glabro, angulis acutissimis, faciebus usque ad medium acute unicostatis. — Texas. — Petals nearly an inch long.

2. G. BIENNIS, L. Caule villosopubescente; calycis segmentis tubum adæquantibus, fauce cum basi styli leviter pilosa; fructu velutino-pubescente basi obtusangulo inter angulos usque ad apicem unicostato. — Canada to Georgia, and Missouri to Texas.

3. G. LONGIFLORA, Spach? (Monogr. Onagr. p. 60): molliter subcinereo-puberula; ramis gracilibus; calycis segmentis tubo duplo longioribus; stylo basi glabella; fructu parvo ovoideo vel obovoideo canescenti-puberulo obtusiuscule angulato. — Texas to Louisiana (Drummond) and Mississippi (Dr. Crockett). — A tall species, like *G. biennis*. Flowers larger than in the following species, but fruit much smaller, only $1\frac{1}{2}$ to 2 lines long. It in no wise deserves the name

of *longiflora*, and perhaps is not the plant which Spach imperfectly characterized. That is said to have the tube of its calyx four lines long, but the anthers only half a line long: the present plant has the former rather shorter, and the latter much longer. I retain the specific name, since it was taken up in *Plantæ Lindheimerianæ*: if incorrect, *microcarpa* would be the most characteristic name.

4. *G. ANGUSTIFOLIA*, Michx. Pilosiuscula vel glabrata, gracilis; foliis repandis sæpe undulatis; calycis segmentis, tubum adæquantibus; *antheris brevi-oblongis*; stylo basi glabro; fructu puberulo ovato oblongo acutissime 3-4-angulato basi breviter attenuato, faciebus usque ad medium unicostatis. — North Carolina to Florida and Louisiana. — Petals not more than two lines long. Flowers frequently trimerous, the fruit (three lines long) then triquetrous.

++ ++ *Rhachis fructu delapso cicatricibus (seu pedicillis brevissimis adnatis) prominulis cupuliformibus squarrosa. Fructus pyramidatus ad latera pl. m. corrugatus. Appendices staminum majusculi.*

5. *G. SUFFULTA*, Engelm. (in Gray, Pl. Lindh. 2. p. 190). Caule hirsuto; foliis inferioribus sæpe sinuato-pinnatifidis; stylo basi subglabro indusio quadripartito superne a stigmate libero; fructu ovato pyramidato acutissime tetraquetro, faciebus concavis parce corrugatis costa gracili percursis. — Texas. — Flowers rarely trimerous.

6. *G. TRIPETALA*, Cav. (Gray, Pl. Wright. 1. p. 72). Caule gracili hirsuto; indusio stigmatis prorsus adnato; fructu pyramidato acutissime triquetro, faciebus parum concavis valde rugosis costa superne demum evanida percursis. — *G. triangulata*, Buckley, Proceed. Acad. Philad., Dec. 1861. — Texas. Mexico.

+ + *Fructus (permaturus) infra medium in collum teres subito contractus, superne pyramidatus. — E radice perenni multicaules, humiles.*

7. *G. COCCINEA*, Nutt. Canescens, foliosissima; radice lignescente; bracteis persistentibus flores adæquantibus; calycis segmentis tubo paulo longioribus; stylo basi piloso; indusio stigmatis annulari margine integerrimo; fructu canescente inferne in collum crassum contracto. — *G. epilobioides*, H. B. K. is probably but a form of this. — Saskatchewan to Texas and Mexico.

8. *G. DRUMMONDII*, Torr. & Gray (*Schizocarya*, Spach). Glabella vel puberula; bracteis caducis; calycis segmentis tubo duplo longioribus, fauce cum basi styli tomentosa; appendicibus staminum petalis antepositorum cæteris manifeste brevioribus; indusio stigmatis quadripartito superne libero; fructu glabro superne conico-pyramidato inferne in collum angustum pedicelliforme contracto. — Texas and New Mexico.

* * *Fructus in pedicellum manifestum clavato-attenuatus vel contractus.*

9. *G. FILIPES*, Spach (Monog. Onagr. p. 59). Puberula vel glabrata, habitu et foliis *G. angustifoliæ*; calycis segmentis tubo elongato clavato paulo longioribus; stylo basi subglabro; fructu parvo superne ovate-pyramidato apice obtuso basi in pedicellum clavatum contracto. — Virginia and Ohio to Florida and Arkansas. — This species is most nearly related to *G. angustifolia*; but besides its pedicellate fruit, which makes it necessary to refer it to this section, the anthers are oblong-linear.

10. *G. SINUATA*, Nutt. Glabra; caule superne nudo; foliis præsertim infimis sæpe sinuato-pinnatifidis; calycis segmentis tubo breviconico 2–3-plo longioribus; stylo basi creberrime villosa; fructu glabro immaturo fusiformi obtusangulo, costis inter angulis obsoletis. — Arkansas and Texas.

11. *G. VILLOSA*, Torr. Canescenti-pubescens, caule nunc villosa; calycis segmentis tubo brevissime obconico quadruplo longioribus; fructu glabro ovato-oblongo tetraquetra inter angulos acutissimos ecostato. — Texas and Arkansas. — Root truly perennial.

12. *G. MACROCARPA*, sp. nov. Caulibus e radice perenni ramulisque pube hirtella scabris; foliis parvis integris margine hispidulis; calycis segmentis tubo paulo longioribus; fructu (haud maturo) canescenti-puberulo fusiformi, obtusangulo costis validis inter angulos percurso. — Southwestern Texas. Wright (No. 1879), Bigelow; — referred to *G. villosa* in Pl. Wrightianæ, 2. p. 59, and in Bot. Mex. Bound. Survey, No. 375.

Leaves rather thick, obtuse, with the revolute margins hispidly ciliate; lower ones 10 lines long, 1 to 2 lines wide, with one or two strong teeth on either edge; upper ones entire, and gradually reduced to bracts. Fruit and pedicel together 8 lines long, subterete, strongly 4-costate. Inflorescence racemose, or in older specimens in a contracted panicle.

§ 2. *Antheræ ovals, retusæ, medio affixæ: inflorescentia spicata, floribus minimis: stigmata ultra indusium haud vel vix producta.*

13. *G. PARVIFLORA*, Dougl. Caule pilis longis patentibus villosus; foliis utrinque adpresse velutinis ciliatis; indusio quadripartito, lobis basi dilatatis; fructu oblongo sessili velutino valde obtusangulo inter angulos unicostato. — Head-waters of the Platte to Louisiana and Texas. — Wallawallah, Oregon, Douglas, ex Hook. Fl. Bor.-Am.

HETEROGAURA, gen. nov.

Calycis tubus brevis, obconicus. Stamina erecta, 4 petalis alterna fertilia antheris ovato-cordatis, retusis; 4 petalis opposita breviora fere ananthera, antheris abortivis lanceolato-cordatis acutissimis: filamenta clavata, exappendiculata. Stylus stamina adæquans: stigma disciforme integerrimum, indusio nullo. Ovarium 4-loculare; loculis uniovulatis. Fructus ovato-gibbosus, 2-4-locularis, abortu 1- (vel 2?-) spermus. — Herba annua, erecta, superne paniculato-ramosa. Folia subintegerrima vel parce obsolete sinuato-dentata; inferiora petiolata, lanceolata; superiora lanceolata-linearia, sessilia vel subsessilia. Ovaria (cum ramulis junioribus) puberula.

H. CALIFORNICA. *Gaura heterandra*, Torr. in Pacif. R. R. Reports, 4. p. 87. — Mokelumne Hill, California, Dr. J. M. Bigelow, May. — Plant one or two feet high, and with habit entirely different from *Gaura*, rather that of *Clarkia*.

Five hundred and thirty-eighth Meeting.

September 13, 1864. — ADJOURNED STATUTE MEETING.

The PRESIDENT in the chair.

Colonel J. D. Graham, of the Corps of Engineers, U. S. Army, in alluding to the semi-diurnal lunar tide lately discovered by him in Lake Michigan, and published in his Reports from 1858 to 1863, remarked, that while in charge as Superintendent of the Survey of the Northern and Northwestern Lakes, he had instituted a series of observations for the purpose of ascertaining, with accuracy, the extent of the similar tide in Lake Huron.

"For this purpose two delicate tide-gauges were established on that lake in October, 1861, and were observed on both day and night until late in December, 1863, — a period of more than two years, — without any other interruption than that which unavoidably arose from the ice in the severe winter months in that climate.

"The observations, as in the case of the previous ones on Lake Michigan, were made with great regularity, at intervals of half an hour of time, except that at certain phases of the moon the intervals were reduced to fifteen minutes of time apart.

"The positions selected for the two observing stations were the wharf at Tawas City, on Tawas Bay, and Thunder Bay Island; the former situated in latitude $44^{\circ} 15' 12''$ N., and the latter in latitude $45^{\circ} 2' 17''$ N.

"These observations have not yet been reduced, but a general examination of them shows that they develop the existence, in Lake Huron, of a semi-diurnal lunar tide, and also a semi-diurnal solar tide, which is separable from that produced by the combined action of the sun and moon, as has been shown in regard to the tide in Lake Michigan.

"It is worthy of notice that no observations have, as far as we know, ever been instituted by the philosophers of the Old World to ascertain the existence and extent of any similar phenomenon in the waters of the Caspian Sea. This sea is a perfect lake; that is to say, it is not connected with any other body of water. It is the largest and deepest lake known on our globe. Its area is greater than the areas of all our Northern and Northwestern lakes added together, and its greatest depth is more than twice that of Lake Superior, the largest and deepest of our North American lakes. The Caspian, therefore, offers peculiar advantages for investigations concerning the theory of the tides, and it might perhaps be not inappropriate for the Academy to invite the attention of foreign scientific societies to the importance of a series of tidal observations there."

On the motion of Mr. F. H. Storer, it was voted that our Secretary be directed to correspond with the Secretary of the Academy of St. Petersburg, for information respecting the tides of the Caspian and other seas of the Eastern continent.

Five hundred and thirty-ninth Meeting.

September 20, 1864. — ADJOURNED STATUTE MEETING.

The PRESIDENT in the chair.

Professor Lovering, from the Committee of Publication, reported that the price of the *Memoirs of the Academy* had been fixed at eight dollars per volume, and the price of the *Proceedings* at two dollars per volume; members being provided with copies, according to a standing vote, at half these prices.

Mr. Bowditch reported from the Committee of Finance a recommendation to raise the salary of the Assistant Librarian to six hundred dollars; and this recommendation was adopted.

A list of the duplicates in the Library, prepared by the Assistant Librarian, was referred to the Committee on the Library, with powers to effect exchanges.

Mr. George Livermore was elected Treasurer of the Academy, in place of Mr. Wigglesworth, resigned; and on the motion of Mr. Bowditch, the following vote was passed: —

“Whereas, Edward Wigglesworth, Esq. has been compelled by ill-health to resign the office of Treasurer of the Academy, — *Voted*, that the Auditing Committee, Messrs. T. T. Bouvé and Dr. Ware, be instructed to audit his accounts and receive from him the property of the Academy which he has in charge, and give him their receipt for the same, and deliver said property to his successor.

On the motion of Mr. E. C. Cabot, it was voted that the thanks of the American Academy be expressed to Mr. Wigglesworth for his services as Treasurer, and that the Fellows deeply regret the ill-health which has rendered his withdrawal from the office necessary.

Professor Winlock made the following communication: —

“I wish to call the attention of the Academy for a moment to a paper read at a recent meeting, on the Right Ascension of the Pole Star. This paper contained a criticism on the investigation from which is derived the mean place of this star used in the computations

of the American Nautical Almanac, and a statement that the elements there used are erroneous.

It is not my intention to enter upon any extended examination of this paper, on which Mr. Safford seems to have bestowed much labor, nor, at present, to express any opinion upon the justness of his criticism or the correctness of his conclusions ; but simply to call attention to the magnitude of the error which he claims to have detected, and to show to what extent the usefulness of the Nautical Almanac has been impaired by the alleged error, if Mr. Safford is right.

I am led to do this by the apprehension that the impression may have been given that some serious injury has been done to the public service by the use of an erroneous value of the place of this star on the part of the Coast Survey, the National Observatory, and the Nautical Almanac, — or that there is some culpable and important uncertainty about a fundamental element in astronomy. This apprehension is justified by the fact that it has since been published in pamphlet form, with a preface by Professor Bond, in which Professor Bond states that this matter is of moment to American astronomers, because the alleged erroneous value of the mean R. A. of the Pole Star has been adopted by the public institutions above mentioned.

Mr. Safford treats of the use of the Almanac place as leading to errors of *prediction*, and presents the nearer fulfilment of his predictions as confirmation of the superiority of his determination of the element in question. The phenomenon *predicted* is the appearance of the Pole Star on the meridian. Now to form a distinct idea of the consequence of the use of false data we must examine its effect on this appearance.

The motion of the Pole Star is so slow, in consequence of its proximity to the pole, that an error of time in a *prediction* which would be quite considerable in some questions in astronomy would here correspond to a very small change of place of the star, or a very slight difference in the appearance to the observer. Thus a second of time would only correspond to a change of position amounting to about one third of a second of space. We will now consider how small a quantity a second of space is. The following illustration will place it before the mind quite distinctly. If a human hair supposed to measure $\frac{1}{256}$ of an inch in diameter were placed at the distance of 86 feet from the eye, its thickness would subtend an angle at the eye of 1", and would shut out just that amount of celestial space.

If now we compare the prediction of a transit of Polaris made from
VOL. VI.

Mr. Safford's mean place with one made from that used in the Nautical Almanac, at the epoch of Dr. Gould's computations, the beginning of the year 1855, and call Mr. Safford's the true and the other the fictitious Pole Star, the interval elapsed between the transits of the two stars would be $0^s.64$, and the space between them would be $0''.2363$, which would represent the difference between the two predictions as it would appear to the eye of the observer. Now a hair of the dimensions above given, placed at the distance of 364 feet from the observer, would entirely cover this space, while the same hair, removed to nearly twice this distance, or 665 feet, would cover the space between Gould's Pole Star and Bessel's at the same epoch. If we make the comparison for a date ten years later, the beginning of the year 1865, near the epoch of Mr. Safford's computation, made with the additional data obtained in ten years, we find that the difference in the times of prediction between Mr. Safford and the Almanac would be about one second of time, and the distance apart of the two stars about one third of a second of arc, which would be completely occulted by a hair at the distance of 233 feet.

Now if we compare the American Ephemeris place with the British Almanac place for the beginning of the year 1865, which latter place I believe was deduced by Mr. Adams, we find the difference between the times of prediction to be $0^s.47$, and the difference of the phenomena, $0''.17$, would be entirely shut out of view by a hair at the distance of 495 feet. Or if there were five Pole Stars that should come to the meridian at the different times corresponding to the predictions of Safford, Bessel, Adams, the American Nautical Almanac, and the Berlin Jahrbuch respectively, no meridian instrument with which the Pole Star was ever observed would separate the components of the multiple star which they would form. And if there were two Pole Stars, one in the place assigned by the British Almanac, and the other in that fixed by the American Ephemeris, they would not be separated by any telescope in existence. If they were reduced to the 10th or 11th magnitude, and all circumstances were favorable, and Mr. Clark's great 18-inch glass were used by Mr. Clark himself as the observer, they could not *possibly* be separated; and the same is true of the Berlin Jahrbuch place. It will thus appear that for all the purposes for which a Nautical Almanac is designed, or for which the Coast Survey may use a star, the place adopted will be found sufficiently near the truth for the present. This star is one of a catalogue of two hundred stars prepared for the use of the

United States Coast Survey, and which has been adopted by the Nautical Almanac. They seemed well selected, their places were derived from observations up to 1851 by an American astronomer entitled to confidence, the investigations were published in detail, open to criticism, and inviting it, thus satisfying all the conditions of a safe catalogue to be adopted by the Nautical Almanac. It was expected that the places would be improved from time to time by the aid of later observations, but I can see nothing in the paper of Mr. Safford, in which he uses the additional observations of the last ten years, to convince me that the place of this star should now be changed from that adopted. And certainly the necessity of such a minute change cannot be considered as demonstrated. There are so many nice points in the combination of the work of different observers and different instruments, and so much is arbitrary, or dependent on the judgment of the computer, that the existence of a magnitude which is less than the personal equations of the observers, especially when it is not visible with the aid of the instruments employed, is extremely difficult to prove, and it is much more difficult to measure such a magnitude. In fact, the accuracy that appears to be reached by such a combination of observations by the method of least squares is often illusory, and is over-estimated by many astronomers. I doubt the possibility of measuring with any degree of accuracy a quantity which cannot be distinguished from zero by the sense employed in measuring it. The limit of exactness of measuring must lie very near the limit of distinct perception, and no repetition of observations can carry our knowledge much beyond it; and if, in the record of observations, a show of precision is kept up beyond this limit, nothing is added to the probability of the resulting value, but the reverse. This is not inconsistent with the doctrine of probabilities embodied in the method of least squares. The rigorous theory assumes continuity of error; and it also implies that in each observation there is some tendency or attraction toward the true value sought. Now this effect or attraction of the thing observed can only be operative within the limit of sensibility, and that part of each observation which is under this limit, and which we cannot know to be produced or influenced in some way by the object observed, might as well be appended arbitrarily or by the cast of a die. To expect to add anything to our knowledge by taking the mean of these would be hoping to coin pure ignorance into knowledge by the method of least squares.

And furthermore it is obvious from these considerations, and from

the failure of the continuity of error, that the distribution of errors in accordance with the law prescribed by theory must fail unless they are counted within limits which include the limit of sensibility.

I do not wish to be understood in these remarks as under-estimating the value of such investigations as these on the Pole Star, or the usefulness of repeated attempts to reach the utmost limits of refinement attainable by computation, nor as depreciating the importance of watchful criticism of one another on the part of astronomers. But, as I have said, I was apprehensive that some who are not astronomers, from the circumstances attending the publication of Mr. Safford's paper, might attach to his correction of the place of the Pole Star a *practical* importance which I think Mr. Safford himself would not claim for it, and might needlessly fear that the Nautical Almanac, the Coast Survey, and the National Observatory had suffered injury from the use of an erroneous element.

Five hundred and fortieth Meeting.

October 11, 1864. — MONTHLY MEETING.

The PRESIDENT in the chair.

Dr. Pickering made the following communication : —

"After finding the names of lunar months in 1 Kings vi. 1 to 38, and viii. 2 (Chron. Obs. on Animals and Plants, p. 165), I was led to suspect that one of the measures of Jeroboam to prevent the reunion of the Hebrew people was the introduction of the Lunar calendar.

"Commencing a calculation by this calendar, I found in the death of the king of Israel and the king of Judah, both by the hand of Jehu, the seeming discrepance of three years in the Bible reduced to B. C. 877 y. $357\frac{5}{8}$ d. — 877 y. $317\frac{344}{660}$ d. = less than forty days.

"Continuing the calculation until the capture of Jerusalem by Jehoshaphat, I found that King Amaziah was permitted to live after this event 'fifteen years' = half the so-called Muslim cycle, 'thirty years of twelve lunations = 10,631 days.' I was further surprised at finding that this half did not leave a fractional day, = 14 Julian years 202 days. A further reduction being even possible, $7\frac{1}{2}$ lunar years or ninety lunations = 7 Julian years 101 days.

"Here then was the means of substituting one calendar for another without interrupting a reckoning in lunations. And in Eastern coun-

tries, where the public observance of the lunations is part of the duty of government, the change may have been repeatedly effected.

“After the capture of Jerusalem by Jehoash, the calendar of Israel was imposed on Judah, the Biblical computation thenceforward being exclusively in lunar years; the date of the death of Sennacherib agreeing with that given by Herodotus. Josephus, in seeming opposition to the Bible, gives ‘130 years, 6 months, 10 days’ from the captivity of the ten tribes to the destruction of the temple. If the Biblical account is in lunar years, these give 130 Julian years, 6 lunations, $2\frac{1}{2}$ days. From the destruction of the temple to the second year of Darius, two known points in chronology, is according to the Bible (2 Chron. xxxvi. 21, Hagg. i. 1, Zech. i. 1 to 16, vii. 1 to 5, and Ezr. iv. 24) ‘seventy years’; this is true of lunar years only.”

Mr. C. M. Warren presented two memoirs, and gave the following synopsis of the conclusions arrived at, viz.:—

Under the general title, *Researches on the Volatile Hydrocarbons*, a memoir bearing the following title, viz.: *On the Volatile Hydrocarbons from Coal-tar Naphtha, Oil of Cumin, and Cuminic Acid; with a Preliminary Notice of some of the Facts derived from the Study of the Light Oils from Wood-tar.*

Also, under the same general title, a second memoir bearing the following title, viz.: *On the Influence of C_2H_2 on the Boiling-points in Homologous Series of Hydrocarbons, and in some Series of their Derivatives; including critical Remarks and Observations on Methods of determining Boiling-points.*

In the first memoir I propose to show:—

1. That coal-tar naphtha contains only four hydrocarbons within the range of 80° – 170° C., as taught by Mansfield and confirmed by Ritthausen.
2. That the benzole series within that range of temperature is limited to four members; and does not contain five, as asserted by Church.
3. That these four members have the boiling-points 80° , 110° , 140° , and 170° respectively; and consequently, that the boiling-point difference in this series for an elementary difference of C_2H_2 is 30° ; instead of 22° and a fraction, as alleged by Church.
4. That the body obtained from coal-tar naphtha boiling at 140° is

not identical with cumole from cuminic acid, (as assumed by Mansfield, and generally credited,) nor even isomeric with it; but that it has the formula which has been assigned to xylene.

5. That the body obtained from coal-tar naphtha boiling at 170° is quite a different body from cymole obtained from oil of cumin, (with which it has been considered identical, as was also assumed by Mansfield,) — these bodies differing from each other by C_2H_2 .

6. That cumole from cuminic acid, and cymole from oil of cumin, do not even belong to the benzole series.

7. That the parabenzole of Church was in all probability simply a mixture of benzole and toluole.

In the second memoir it is shown: —

1. That the boiling-point difference for the addition of C_2H_2 in homologous series of hydrocarbons is generally 30° ; which is a much larger difference than has generally been supposed.

2. That, of the five series of hydrocarbons examined, only one series was found exceptional; and this series presents the difference of about 20° ; which is but little larger than the number, 19° , which Kopp found to be so common with other classes of substances.

3. That the formulæ of Schröder, Löwig, and Gerhardt for the calculation of boiling-points, so far as these relate to the hydrocarbons, are purely artificial.

4. That certain series of derivatives from the benzole series of hydrocarbons present boiling-point differences corresponding to an elementary difference of C_2H_2 , considerably smaller than the number 19° of Kopp.

5. That the custom of taking boiling-points with the bulb of the thermometer in the vapor, is more liable to lead to an erroneous determination — at least in certain cases — than if the bulb be placed in the liquid.

Five hundred and forty-first Meeting.

November 9, 1864. — STATUTE MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read a letter from Frederick Overbeck of Rome in acknowledgment of his election into the Academy.

The Treasurer moved the following appropriations for the current year, viz. :—

For general expenses,	\$ 1100.00
For publications,	700.00
For books,	600.00

These appropriations were voted.

Michel Charles of Paris was elected a Foreign Honorary Member in Class I. Section 1, in place of the late M. Plana.

Otto Struve, of the Imperial Russian Observatory at Pulkova, was elected a Foreign Honorary Member in Class I. Section 2, in place of the late M. Ostrogradsky, of Class I. Section 1.

Professor Robert Bunsen of Heidelberg was elected a Foreign Honorary Member in Class I. Section 3, in place of the late Professor Heinrich Rose.

On the motion of Dr. A. A. Gould it was

“Voted, that it would be agreeable to the Academy, and probably useful, to have meetings of a social character in addition to its regular meetings ; and that the Secretaries be authorized to make any needful arrangements in this respect.”

Five hundred and forty-second Meeting.

December 6, 1864. — SPECIAL MEETING.

The PRESIDENT in the chair.

The President called the attention of the Academy to the decease, since the last annual report of the Council, of two members of the Academy,— Hon. Josiah Quincy of the Resident Fellows, and Professor Benjamin Silliman of New Haven, of the Associate Fellows.

Professor Goodwin presented the following paper, entitled,
A Revision of the Doctrine of Conditional Sentences in Greek and Latin.

There is hardly a duty incumbent on scholars more important than that of constantly revising the familiar doctrines which are taught in our schools as a part of elementary instruction. At the same time there are few duties so generally neglected. No amount of labor

ought to be considered wasted by those whose studies lead them in this direction, if thereby a single serious obstacle can be removed from the path of beginners. There is probably no department in which attention to this duty is more needed, than it is in certain parts of grammatical science which form the basis of a classical education. There is no danger that Greek and Latin grammar will ever be so freed from difficulties as to lose their value in mental discipline; discipline can be avoided only by avoiding the study of grammar as a science altogether, by a process of climbing in at the cabin-windows of classical learning, which never yet made a scholar, and never will. But obscurities and inaccuracies are the greatest obstacles to mental discipline; they do not train the mind of youth, they simply discourage and disgust. I believe most firmly that many a youth has been driven in despair from the study of grammar, or has continued it only under a constant mental protest, simply on account of the obstacles that have been left in his way by those whose duty it was to remove them.

It is only by the separate investigation of special points, that we can ever hope to settle definitely the many disputed questions in this or any other science. A little more than half a century ago the rules for the most common iambic metre, which are now printed in large type in every Greek grammar, were the subject of an angry controversy between Hermann and Porson. The prejudices excited by this controversy have hardly yet died away, but the questions are at rest. I propose in this paper to review the doctrines usually taught in our schools on the subject of conditional sentences in Greek and Latin. I take for my text the rules and remarks on this subject which are found in the sixty-fourth edition of the Latin grammar most commonly used in our schools. After defining the terms *protasis* and *apodosis*, and giving (strangely enough at the beginning) a rule for the imperfect and pluperfect subjunctive, which would be correct if it gave any intimation of the time denoted by those tenses, the author gives the following rules for the primary tenses of the subjunctive and the indicative in conditional sentences: —

“2. The present and perfect subjunctive are used in the *protasis*, when the action or state supposed may, or may not, exist, or have existed; as,

“*Omnia brevia tolerabilia esse debent, etiamsi maxima sint, . . . although they may be very great. Cic. Etsi id fugerit Isocrates, at non Thucydides; Although Isocrates may have avoided that . . . Id.*

"Rem. 1. The tenses of the *indicative* may also be used in the *protasis* of a conditional sentence with *si*, &c.; as, *Si vales, bene est. Cic. Si quis antea mirabatur quid esset, ex hoc tempore miratur potius. . . . Id.*

"Rem. 2. The subjunctive after *si*, &c., implies a greater degree of contingency than the indicative. When the imperfect or pluperfect is required to denote a past action, the indicative must be used if its existence is uncertain, as those tenses in the subjunctive would imply its non-existence.

"Rem. 3. The present and perfect subjunctive are sometimes used, both in the *protasis* and *apodosis* of a conditional sentence, in the sense of the imperfect and pluperfect; as, *Tu, si hic sis, aliter sentias; if you were here, you would think otherwise. Ter. Quos, ni mea cura resistat, jam flammae tule-rint. Virg.*"

This is all the information that is given on the matter; and who can wonder that school-boys leave school with the idea that the whole subject is beyond their comprehension? It may be remarked here that the two examples under the main rule do nothing to illustrate the rule, either as it stands or as it should be stated. The first is from Cicero, *Lael. XXVII. 104*, and the *protasis* should read *etiam si magna sunt* (not *maxima sint*), as nearly all manuscripts and editions have it; the subjunctive therefore need not be discussed. The second is merely a *concessive* subjunctive transferred to a *protasis*, and is no more an illustration of the perfect subjunctive in *protasis* than it is of the ablative absolute. The first example under Rem. 3, is a curious case of a quotation which has unjustly suffered by never being referred to its context. It might be asked, how a man who was not present could be addressed in this style; but the mystery will be explained, if any one will turn to the *Andria* of Terence (*II. 1, 10*), where he will see that the passage means, *If you should put yourself in my position, you would think otherwise*; in which sense it is a perfectly good example of a well recognized usage. But we must not be led away by special criticism, our object being to discuss the main principles of conditional sentences.

I. Let us consider the simplest question that arises, — What is the meaning of the indicative in *protasis*, as *si cupit, si hoc facit, ei boůλεται, ei τοũτο πράσσει*? The most common theory is that it expresses *certainty*, or that the supposition is at least assumed to be a fact. This idea, with the misunderstandings that have arisen from it, has perhaps done more than any other to confuse the mind of learners

on this whole subject. It is almost sure to mislead a beginner, when he first meets with it. It seems very plausible, when it is seen in the large print of a grammar, with *si vales, bene est*, or some other standard example to confirm it. But a single example, taken at random from Cicero, is enough to show the falsity of the principle as it is commonly understood:—*Si omnia antecedentibus causis fiunt, omnia naturali conligatione consert econtexteque fiunt; quod si est, omnia necessitas efficit; id si verum est, nihil est in nostra potestate; est autem aliquid in nostra potestate: at si omnia fato fiunt, omnia causis antecedentibus fiunt: non igitur fato fiunt quaecumque fiunt.* CIC. *De Fato*, XIV.

31. Here certainly are four conditions stated in the present indicative, but each is stated only to be proved contrary to fact. It seems evident that such grammarians as Zumpt could never have intended their rule to be thus understood: Zumpt indeed, adds a note (to § 517), in which he explains that what is *assumed* as certain with respect to the inference (*in Bezug auf die Folgerung*) need not be certain either in fact or in the speaker's belief. This modification would carry the principle, even if it were a true one, entirely beyond the reach of those for whose use it is stated; for school-boys will be hardly expected to draw the line very accurately between conditions which can be *assumed as certain* (however incorrectly) and those which cannot. We must recollect also that the "indicative" in such rules includes the future, as well as the present and past; so that in the sentence, *si naturam sequemur ducem, nunquam aberrabimus*, we are to consider the future as used because the certainty of the supposition is assumed. The principle thus modified will therefore amount to nothing more than this useless truism, that when we use the indicative (present, past, or future) in a protasis, we *assume* something as really happening in either present, past, or future time, and then state a conclusion which follows from that assumption. But this would apply to almost any supposition that we can make; it certainly would apply to the subjunctive;—if, (for example) *sequamur* were used for *sequemur* in the sentence given above, the difference would be hardly perceptible, the meaning in both cases being *if we shall follow*. But it is useless to discuss so obvious a matter. The simple truth is that the indicative in such a protasis as we are discussing expresses a *mere supposition*, and nothing more, with no expression of the speaker's opinion as to its truth or falsity. It will express the condition *if all men are liars*, as well as the condition *if truth is eternal*. The time to which the supposition refers is of course

expressed by the tense of the indicative, that mood in both Greek and Latin having a tense for every variety of present, past, and future time.

II. The great cause of obscurity on this point seems to be the difficulty of finding a proper definition of the use of the subjunctive in protasis, and the supposed necessity of putting the indicative in strong antithesis to this mood. Most grammarians assign to the Greek subjunctive in protasis the expression of *possibility*: thus Krüger, whose statement of the use of the indicative is by itself satisfactory, considers the subjunctive to denote "objective possibility"; Madvig says it expresses "what is possible now or in the future." Bäumlein (in his *Untersuchungen über die Griechischen Modi*) considers it in this and in all its uses to denote "a tendency to reality" (*eine Tendenz zur Wirklichkeit*). As to the Latin subjunctive, we find a most remarkable diversity of opinion among the best grammarians. Thus Zumpt says that the present and perfect subjunctive with *si*, &c., imply that the supposition conforms or may conform to the actual fact (*dass die That ihr entspricht, oder entsprechen kann*). Madvig, on the other hand, tells us that the present subjunctive with *si*, &c., expresses a possible condition, which is *supposed* to be realized in the present and future, implying, however, that it *is not or will not be realized in fact*. (His words are, *Das Präsens im Conj. wird gebraucht, wenn man eine noch mögliche Bedingung als jetzt oder in der Zukunft stattfindend annimmt und versuchsweise denkt, aber zugleich bezeichnet, dass sie doch nicht wirklich ist oder werden wird*). This disagreement between two such scholars on so fundamental a matter is a strong proof that they both look for the essential principle of the subjunctive where it cannot be found. Each finds it easy to form or select an example adapted to his own theory. Thus Zumpt gives "*si velit, if he wish, or may wish*, it being implied that he either does wish, or at least may wish,"—and quotes, *Dies deficiat, si velim numerare, &c.* Madvig quotes, *Me dies, vox, latera deficiant, si hoc nunc vociferari velim*, "*as I may do, but do not intend to do*." These specimens will at least show that the question we are discussing is not a settled one, beyond the need of a new investigation.

In one point all these authorities agree,—in looking for some principle on which the use of the subjunctive depends, to be found either in the nature of the act supposed or in the manner in which the speaker conceives it. This, it seems to me, is the rock upon which

they have all split.* After the most careful study that I have been able to give to the subject, and especially after a comparison of several thousand classic examples, I am convinced that no such principle can be found. Every example that I have met with has only confirmed the opinion, which I can now express with the greatest confidence, that there is no inherent distinction between the present indicative and the present subjunctive in protasis (between *εἰ βούλεται* and *ἐὰν βούληται*), except that of *time*.

But before this distinction can be properly applied, another must be understood and kept in view. A supposition may be either *particular* or *general*, that is, it may refer to a definite act (or a definite series of acts) performed at a definite time, or it may refer indefinitely to *any one* of a class of acts. Thus we may say, *If he now has money, he desires to give it*, and also, *If he ever has money, he always desires to give it*: we use the present tense *has* in English in both conditions, but it is obvious that it refers to strictly present time only in the former case, in which we call the supposition *particular*; in the other case it refers to any occasion on which we may suppose the person to have money, and we therefore call this supposition *general*. If now we leave out of account for the present all conditions which express a general supposition, and confine ourselves to those which refer to definite times, we shall find in Greek† the simple rule invariable, that *the subjunctive refers to the future*. Thus *ἐὰν τοῦτο ποιῇ, σοφὸς ἔσται* means *if he shall do this, he will be wise*; whereas *εἰ τοῦτο ποιεῖ, σοφός ἐστιν* means *if he is (now) doing this, he is wise*. In neither case is anything whatever implied *by the construction* as to the opinion of the speaker with regard to the truth or the possibility of the supposition: the context or the nature of the supposition may or may not indicate these things, but the construction itself simply indicates the time. We have seen that the indicative can express a future condition by its future tense. This is merely a

* I cannot claim to have been entirely free from the same error myself; for, in attempting, five years ago, to state the relations of the Greek moods in conditional sentences (*Syntax of the Moods and Tenses of the Greek Verb*, Cambridge, 1860), I could not persuade myself to abandon entirely a principle which nearly all grammarians had accepted in some form, and I reluctantly admitted the idea of *possibility* as distinguishing the subjunctive from the optative.

† In what follows I shall use the Attic Greek as the standard of comparison, for several obvious reasons. The Latin constructions will thus, I think, be more clearly understood.

more vivid form of expressing the same idea; *εἰ τοῦτο ποιήσει* meaning *if he shall do this*, as well as the subjunctive used above, both being expressed in modern English by the less accurate but common form *if he does this*. When Isocrates (Archid. p. 138, A.) says, *ἣν ἐθέλωμεν ἀποθνήσκειν ὑπὲρ τῶν δικαίων, εὐδοκμήσομεν· εἰ δὲ φοβησόμεθα τοὺς κινδύνους, εἰς πολλὰς ταραχὰς καταστήσομεν ἡμᾶς αὐτούς*, what scholar can pretend to see any difference between the subjunctive and the future indicative in the protasis, except that the latter is the more vivid form? The former is *if we shall be willing to die*, the latter *if we shall fear the dangers*. Certainly no one would think that the orator intended to imply that the latter supposition was more in accordance with *fact* than the former. Again, Demosthenes (Aph. I. p. 834, 24) says, *ἀν γὰρ ἀποφύγῃ με οὗτος, ὃ μὴ γένοιτο, τὴν ἐπωβελίαν ὀφλήσω*, *if this defendant shall escape me, and may it not happen*, &c. But in the second part of his argument (Aph. II. p. 842, 15), referring to precisely the same thing, which was quite as contingent, quite as possible, and quite as little matter of fact as it had been before, he says, *εἰ δ' ὑμεῖς ἄλλο τι γνώσεσθε, ὃ μὴ γένοιτο, τίνα αἴεσθε αὐτὴν ψυχὴν ἔξειν*; In Greek both forms are in equally good use, the subjunctive being the more common. In Latin, as the present subjunctive was required to perform the functions of the Greek optative in protasis, we find the future or future perfect indicative the more common form; as, *naturam si sequemur duces, nunquam aberrabimus*, *if we shall follow*, &c. Crc. Offic. I. 28, 100; *si feceris id quod ostendis, magnam habebō gratiam*; *si non feceris, ignoscam*: *quare tu, si simul placebit, statim ad me venies*, Crc. Ep. Fam. V. 19. (The future perfect defines more exactly the action of the protasis as preceding that of the apodosis.) Still the Latin subjunctive is sometimes found in precisely the sense of the Greek; as, *nec si cupias licebit*, Crc. Verr. II. 69, 167, in Greek *οὐδ' ἐὰν βούλῃ ἔξεσται*.

Let us now return to the *general* suppositions which we excluded from consideration at the beginning of the last paragraph. The failure to distinguish these from the particular suppositions which have just been considered seems to have caused the chief confusion that prevails about the distinction between the indicative and subjunctive. As the Greek commonly uses the subjunctive in these, it was thought necessary to bring them into one class with the particular suppositions, and the essential character of the latter (their reference to the future) was thus overlooked; and as we always translate the subjunctive in general

suppositions by the present indicative, the great distinction between their indefinite time and real present time seems to have been forgotten. The Greek regularly expresses these general suppositions by the subjunctive, when they depend on a verb of present time (expressing a repeated action or general truth) and can be translated by the English present; as *ἐάν τι ἔχη, βούλεται τοῦτο δοῦναι*, *if he ever has anything, he (always) wishes to give it*. So *ἢν ἐγγὺς ἔλθῃ θάνατος, οὐδεὶς βούλεται θνήσκειν*, *if death comes near, no one is willing to die*. EUR. Alcest. 671. When they refer to the past, the Greek uses the optative; as *εἰ τι ἔχοι, ἐβούλετο τοῦτο δοῦναι*, *if he ever had anything, he (always) wished to give it*. So, *εἰ δέ τις θορυβούμενος αἴσθοιτο, κατασβεννύναι τὴν παραχῆν ἐπειρᾶτο*, *if he saw any making a disturbance (at any time) he (always) tried, &c.* XEN. Cyr. V. 3, 55. In Latin we sometimes find the same construction, the present and perfect subjunctive being used in the sense of the Greek subjunctive, and the imperfect and pluperfect subjunctive in the sense of the optative. E. g. *Si discordet eques, media inter carmina poscunt aut ursum aut pugiles*. HOR. Epist. II. 1, 185. *Neque aliter si faciat, ullam in suos habet auctoritatem*. CAES. B. G. VI. 11. *Si hastati profigare hostem non possent, eos retro cedentes principes recipiebant*. LIV. VIII. 8, 9. *Si quis a domino prehendetur, concursu militum eripiebatur*. CAES. Bell. Civ. III. 110. But this was not a genuine Latin construction, being seldom found in Cicero and earlier writers, who prefer the simple indicative (as we do in English): it may perhaps be considered an imitation of the Greek. Thus we find the following examples in Caesar, within a few pages of the first example above quoted. *Si qui ex reliquis excellit dignitate, succedit; aut, si sunt plures pares, . . . de principatu contendunt*. Bell. Gall. VI. 13. In the same chapter, *Si quod est admissum facinus, si caedes facta, si de hereditate, de finibus controversia est, idem decernunt; si qui aut privatus aut populus eorum decreto non stetit, sacrificiis interdicunt*. Again in Chapter XIX.: *De morte si res in suspicionem venit, de uxoribus quaestionem habent; et si compertum est, ex cruciatas interficiunt*. So in Horace, Serm. I. 4, 3, we find, *Si quis dignus erat describi, multa cum libertate notabant*. These last examples illustrate the true Latin construction. The Greek sometimes uses the indicative in the same way, but only as an exception; of course it is sometimes difficult to draw the line between a supposition that is thus general in its nature and one that is really present.

III. We have seen that the Greek can express a future condition

in two ways, by the subjunctive or by the more vivid future indicative ; *ἐάν βούληται* and *εἰ βουλήσεται* both meaning *if he shall wish*, and being commonly expressed in English by *if he wishes*. But the Greek, like the English, can express the same supposition in a still vaguer form than the subjunctive,—by the optative *εἰ βούλοιτο*, *if he should wish*, to which the natural conclusion is a corresponding form in the optative with *ἄν*, as *τοῦτ' ἄν ποιίῃ*. It is commonly assumed that there is some metaphysical distinction between the subjunctive and optative in a protasis of this kind ; thus Krüger defines the subjunctive as expressing “objective possibility,” and the optative as expressing “subjective uncertainty.” Bäumlein, who defines the subjunctive (in all its uses) as expressing “a tendency to reality,” defines the optative as expressing “pure subjectivity” (*reine Subjectivität*). Now the distinction is perfectly preserved in the English *if he shall go* and *if he should go*, and it is easy for any one to ask himself what distinction he makes between these familiar forms. It will probably not be easy to state precisely what the difference is, but I think very few will decide that it agrees with either of the definitions quoted above. Perhaps the most familiar distinction is that given by Buttmann, that *ἐάν* with the subjunctive implies “possibility with a prospect of decision,” while the optative implies possibility without any such prospect. It is one of the most difficult things in the world to state in words the difference which every one feels between *if he shall go* and *if he should go* ; and it is for this very reason easy to imagine that it is this or any other impalpable difference that may be suggested. But it would be hard to convince an ordinary man, who had no idea of the corresponding Greek forms, that this is the distinction that he makes in his use of English. Does the proverb, *If the sky falls (shall fall), we shall catch larks*, imply any nearer “prospect of decision” than it would in the form, *If the sky should fall, we should catch larks* ? Did Demosthenes (Phil. I. p. 43) intend to imply that there was any nearer “prospect of a decision” on the question of Philip’s assassination, when he referred to it in the words *ἂν οὗτός τι πράθῃ*, than when in the very next sentence he repeated his supposition in the form *εἰ τι πράθοι* ? On the contrary, the more the subject is considered, the clearer it will become (I think), that the optative in protasis is merely a *vaguer* form than the subjunctive for stating the same supposition, bearing, in fact, almost the same relation to the subjunctive that the subjunctive bears to the future indicative. Thus we have three forms which may be used to express a

future condition, differing merely in the vividness with which they state the supposition, — *εἰ τοῦτο γενήσεται*, *if this shall happen*; *ἐὰν τοῦτο γένηται*, *if this happens* (i. e., *shall happen*); and *εἰ τοῦτο γένοιτο*, *if this should happen*.

Now the Latin, not having the same abundance of forms as the Greek, commonly uses its present subjunctive in both protasis and apodosis as the equivalent of the Greek optative; as, *dies deficiat, si velim numerare*, &c., *the day would fail me, if I should wish to enumerate*, &c. The adverb *ἄν*, used in Greek to mark the apodosis, has no equivalent in Latin. We have already seen that the Latin subjunctive is sometimes used as the equivalent of the Greek subjunctive, as in the example, *nec si cupias licebit*; but this is an exceptional use, the future or future perfect indicative being the ordinary form. Still this fact that the Latin could use its subjunctive to express both the subjunctive and the optative in Greek is a strong proof that no such metaphysical distinction as is commonly supposed existed between the last two.

The Greek optative and the Latin subjunctive can of course express general suppositions; but as the form would not differ from that of particular suppositions in this case, they present no peculiarities which require notice here.

IV. There remain to be considered those forms of present and past conditions which imply that the condition *is not* or *was not fulfilled*. Here the Greek uses the past tenses of the indicative in both protasis and apodosis, with *ἄν* in the apodosis; the Latin uses the imperfect and pluperfect subjunctive. The Greek uses the imperfect indicative to express continued or repeated action in either present or past time, and the aorist (rarely the pluperfect) to express single or momentary action in past time; the Latin uses the imperfect subjunctive to refer to the present, the pluperfect to refer to the past. Thus, *ταῦτα οὐκ ἂν ἐδύναντο ποιεῖν, εἰ μὴ διαίτη μετρία ἐχρῶντο*, *they would not be able to do this (as they do), if they did not lead an abstemious life*, XEN. Cyr. I. 2, 16: *οὐκ ἂν νήσων ἐκράτει, εἰ μὴ ναυτικὸν εἶχεν*, *he would not have been master of the islands, if he had not had a navy*, THUC. I. 9: *εἰ ὁ Φίλιππος ταύτην ἔσχε τὴν γνώμην, οὐδὲν ἂν ὧν νυνὶ πεποίηκεν ἔπραξεν*, *if Philip had formed this opinion, he would have done nothing of what he has done*, DEM. Phil. I. p. 41, 18. A caution is necessary here against introducing the idea of *possibility* or *impossibility* into our definition of this construction. The construction implies merely that the condition *is not* or *was not fulfilled*; the supposition

made in the protasis may be a *possible* one or not, according to the circumstances. Thus the suppositions made in the three examples above quoted, although they are contrary to fact, are still perfectly *possible* suppositions ; while, on the other hand, we use the same construction to express *εἰ τὰ δώδεκα δις πέντε ἦν*, *if twelve were twice five*, which we cannot even imagine to be true.

It will be remembered that the two tenses of the Greek subjunctive and optative which are most frequently employed in conditional sentences, the present and the aorist, differ here only by the present expressing a continued or repeated action, and the aorist expressing a momentary or single action ; the perfect denoting the *completion* of an action at the time at which the present or aorist would denote simply its *occurrence*. This distinction between the present and aorist is wanting in Latin, the present subjunctive there performing the duties of both present and aorist in Greek. In particular suppositions, the Latin present subjunctive corresponds to the Greek present and aorist optative, and occasionally to the present and aorist subjunctive ; the perfect (when it occurs) corresponding in general to the perfect optative or subjunctive. In general suppositions, the Latin present subjunctive corresponds to the Greek present and aorist subjunctive, and the Latin imperfect subjunctive to the Greek present and aorist optative.* Further, in the forms of protasis which imply the non-fulfilment of the condition, the Latin imperfect and pluperfect subjunctive correspond to the Greek imperfect and aorist (rarely pluperfect) indicative.

In practice it will be found most convenient to divide conditional sentences into those with *particular* suppositions and those with *general* suppositions, and then to subdivide the former into those expressing *present* or *past* conditions and those expressing *future* conditions. The following table will give a general view of the whole.

I. PARTICULAR SUPPOSITIONS.

A. Present and Past Conditions.

1. *Simple supposition, implying nothing as to fulfilment of condition :—*

Present and past tenses of the indicative in protasis ; any tense of

* For the relations of the Greek optative to the subjunctive, and a comparison of both with the Latin subjunctive, see *Proceedings*, Vol. V. pp. 96–102.

the indicative (or the imperative, or any form expressing a wish or exhortation) in the apodosis; — the same in both Greek and Latin. E. g.

Εἰ τοῦτο πράσσει, καλῶς ἔχει, si hoc facit, bene est; *if he is doing this, it is well.* Εἰ τοῦτο ἔπραξε, καλῶς ἔχει (εἶχεν or ἔσχεν), si hoc fecit, bene est (erat or fuit); *if he did this, it is (or was) well.*

2. *Implying non-fulfilment of condition:—*

Past tenses of the indicative (with ἄν in the apodosis) in Greek; imperfect and pluperfect subjunctive in Latin. E. g.

Εἰ τοῦτο ἔπρασσε, καλῶς ἂν εἶχεν, si hoc faceret, bene esset; *if he were doing this, it would be well.* (The same Greek may also refer to repeated or continued action in past time, when it will be equivalent to si hoc fecisset, bene fuisset). Εἰ τοῦτο ἔπραξε, καλῶς ἂν ἔσχεν, si hoc fecisset, bene fuisset; *if he had done this, it would have been well.*

B. Future Conditions.

1. *More vivid form:—simple supposition referring to future time.*

In protasis, — subjunctive (with εἰ) or future indicative (with εἰ) in Greek, future or future-perfect indicative (sometimes present or perfect subjunctive) in Latin. In apodosis, future indicative (or some other form denoting future time) in both Greek and Latin. E. g.

Ἐὰν τοῦτο πράσσῃ (or πράξῃ), καλῶς ἔξει, *if he shall do this, it will be well.* Εἰ τοῦτο πράξεις, καλῶς ἔξει, *if he shall do this, it will be well.* (Both forms are equally good in Greek.)

Si hoc faciet (or fecerit), bene erit (sometimes si hoc faciat, bene erit), *if he shall do this (or shall have done this), it will be well.*

2. *Less vivid form:—*

In Greek, optative (any tense except the future) in both protasis and apodosis (with ἄν in apodosis); in Latin, present or perfect subjunctive in both protasis and apodosis. E. g.

Εἰ τοῦτο πράσσοι (or πράξειε), καλῶς ἂν ἔχοι, si hoc faciat, bene sit; *if he should do this, it would be well.* Εἰ τοῦτο ἀρνηθεῖν, ψευδοίμην ἂν, si hoc negem, mentiar; *if I should deny this, I should lie.*

II. GENERAL SUPPOSITIONS.

1. *Referring to indefinite time (expressed in English by present), and depending on a verb of present time which expresses repeated or customary action or a general truth.*

In Greek, subjunctive (with εἰ), rarely present indicative. In

Latin, present or perfect indicative, sometimes subjunctive; latter seldom in Cicero and earlier writers. E. g.

Ἐάν τις αὐτὸν ἀδικῇ, μισεῖ, *if any one (ever) wrongs him, he (always) hates him.* Ἄπας λόγος, ἂν ἀπῇ τὰ πράγματα, ματαιὸν τι φαίνεται, *all speech, if deeds are wanting, appears vain.* DEM. OL. II. 21, 20. Si qui ex reliquis excellit dignitate, succedit; si sunt plures pares, . . . de principatu contendunt. CAES. B. G. VI. 13. See other examples, including cases of the subjunctive, above, p. 370.

2. Referring to indefinite past time, and depending on a past verb which expresses repeated or customary action or a general truth.

In Greek, optative (with εἰ), rarely past tense of indicative. In Latin, past tenses of indicative, sometimes past tenses of subjunctive. E. g.

Εἴ τις αὐτὸν ἀδικοίη (or ἀδικήσειεν), ἐμίσει, *if any one (ever) wronged him, he (always) hated him.* Si quis dignus erat describi, notabant. Si quis prehenderetur, eripiebatur. See other examples above, p. 370.

When conditional sentences are thus classified, it is easy to see the close correspondence which appears in Greek between them and the various forms of conditional relative and temporal sentences. Each form will be stated, under the same designations which are used in the preceding table.

I. A. 1. Ὅτι ἔχει δώσει, *whatever he (now) has he will give.* Ὅτι εἶχεν ἔδωκεν, *whatever he had he gave.* Ἀ μὴ οἶδα οὐδ' οἶμαι εἶδέναι, *what I do not know I do not even think I know.* These relative sentences correspond in form to εἴ τι ἔχει, εἴ τι εἶχεν, and εἴ τινα μὴ οἶδα.

2. Ὅτι εἶχεν ἔδωκεν ἂν, *whatever he had had he would have given;* corresponding to εἴ τι εἶχεν, *if he had had anything.* Οὐκ ἂν ἐπεχειροῦμεν πράττειν ἂ μὴ ἡπιστάμεθα, *we should not then be undertaking (as we now are) to do what we did not understand;* like εἴ τινα μὴ ἡπιστάμεθα, *if we did not understand certain things* (the whole supposition of the sentence being contrary to fact).

B. 1. Ὅτι ἂν ἔχῃ δώσει, *whatever he shall have he will give;* like εἰάν τι ἔχῃ. Ἐπειδὴν διαπράξωμαι ταῦτα, ἤξω, *when I shall have accomplished this, I will come;* like εἰάν ποτε διαπράξωμαι. Ὡς ἂν εἴπω, πειθώμεθα, *let us obey as I shall direct;* like εἰάν πως εἴπω.

The future indicative, which is very common in ordinary protasis of this class, very rarely occurs in these relative and temporal clauses.

2. Ὅτι ἔχοι δοῖν ἄν, *he would give whatever he might have*; like εἰ τι ἔχοι, *if he should have anything*. Δύναιτο γὰρ ἄν, ὁπότε βούλοιο, τοῦτο ποιεῖν, *for he would be able to do this whenever he might please*; like εἰ ποτε βούλοιο, *if ever he should please*.

II. 1. Ὅτι ἂν ἔχη διδωσι, *whatever he has (at any time) he gives*; like εἰ τι ἔχη, *if he (ever) has anything*. Συμμαχεῖν τοῖσι ἐθέλουσιν ἅπαντες, οὓς ἂν ὀράσι παρεσκευασμένους, *those whom they (at any time) see prepared*; like εἰ τινας ὀρώσιν.

Here we sometimes find the indicative, especially after ὅστις, that pronoun expressing the indefiniteness sufficiently without help from the verb. See SOPH. Antig. 178; and compare Od. XIV. 157 with II. IX. 313.

2. Ὅτι ἔχοι ἐδίδου, *whatever he had (at any time) he (always) gave*; like εἰ τι ἔχοι. Οὓς ἴδοι εὐτάκτως ἴοντας ἐπῆναι, *he (always) praised those whom he saw marching in good order*; like εἰ τινας ἴδοι.*

I have attempted, in the preceding remarks, to call attention to the general principles which govern the constructions in question, leaving out of account all real or apparent exceptions which would tend to obscure the principles themselves. It is seldom that any language will allow its principles of construction to be stated so accurately that no exceptions will have to be made; if such a case is to be found, it is in the Attic Greek, and in the constructions which are here discussed. In the Homeric language, which is much less accurate in its use of the moods and tenses, and in some respects less complete (having for example no future optative), we find many constructions which would be impossible in the Attic Greek; and the same is true of the Latin, which never attempted such accuracy in the expression of thought as its sister language. The introduction of these exceptional constructions in too prominent a position has often greatly interfered with a right understanding of the regular forms in both languages.

In conclusion I would add a few remarks on the English subjunctive in conditional sentences. The modern English, especially the spoken language, makes no distinction between present and future time in protasis, *if he does this* being used to express all the various meanings which the Greek expresses by εἰ τοῦτο πράσσει, εἰ πράξει, and εἰ πράσσει (or πράξει),

* Although the Latin agrees with the Greek in several of these constructions, still the peculiarities of the use of the subjunctive in Latin relative sentences are so great, that it would have created confusion to include them in the table.

and the Latin by *si facit* and *si faciet* (or *fecerit*). The Commonwealth of Massachusetts recently abolished the subjunctive as well as the future indicative in protasis, as far as it could, by expunging both from its statute-books, so that now our laws have, "Whoever *steals*," "If a clerk *embezzles*," &c., instead of the time-honored forms, "Whoever shall steal," "If a clerk shall embezzle" (or "If a clerk embezzle"). In the riot act we find: "If any persons . . . *are* unlawfully, riotously, or tumultuously assembled in any city or town," &c. In Athens at least a law thus expressed would have been worthless against any rioters who were not already assembled when the law was passed. Still there is no doubt that this is the common English form, authorized by modern usage; although it is to be regretted that our language should lose its power of expressing nice distinctions of thought, — a power which especially distinguishes the ancient languages, and the Greek pre-eminently, from the modern. For example, the English sentence, *he said that, if they should pass this vote, the State would be safe*, could be expressed in Greek in twelve or more distinct forms, each depending on some delicate shade of meaning which no modern language would attempt to express, the changes being confined to the last two verbs. It is one mark of the degeneracy of the modern Greek that it has lost the ancient distinction between the subjunctive and the indicative; *γράφει* and *γράφη*, not being distinguished in pronunciation, have now lost their distinctive force to the mass of the people. The scholars in Greece are doing their best to revive this, as well as other distinctions of the ancient language of their country, by observing the proper spelling in the written language; it would seem as if our tendency were rather to abolish whatever distinction of the kind has been left to us, and to make our present indicative do the work of both present and future.

Still the English has a subjunctive, which is distinguished from the indicative in most verbs only in the third person singular; and it is still in good use, although it is to be feared that the levelling power of custom will soon obliterate it entirely. But on what principle do modern writers use the English subjunctive after *if*? I think that many writers would admit that they use it without thinking of any special distinction between *if it be* and *if it is*; while others are influenced by the supposed distinction between the corresponding classic forms, *if it be* being used where doubt is to be expressed, *if it is* where the writer believes his supposition is correct. How far such a distinction in English is now authorized by usage I will not pretend to say; it has been one of the

chief objects of this paper to show that no such distinction is found in either Greek or Latin.

If we look at the English translation of the Bible, which represents the language when the subjunctive was in full use, we find the Greek subjunctive in the New Testament invariably translated by the subjunctive or the future (except where it is expressed by a participle), never by the present indicative. But this investigation proves too much; for the same translation is equally consistent in expressing the Greek present indicative by the English subjunctive. Thus, *if it fall*, — *if any man shall say unto you*, — *if a house be divided*, — *if any man say unto you*, — *if thy brother trespass against thee, rebuke him, and if he repent, forgive him*, — *if another shall come*, — are translated from ἐὰν ἐμπέσῃ, — ἐὰν τις εἴπῃ, — ἐὰν οἰκία μερισθῇ, — ἐὰν τις εἴπῃ, — ἐὰν ἁμάρτη ὁ ἀδελφός σου, ... καὶ ἐὰν μετανοήσῃ, — ἐὰν ἄλλος ἔλθῃ. But we also find, *if the light that is in thee be darkness*, εἰ τὸ φῶς σκότος ἐστίν, — *if Satan cast out Satan*, εἰ ἐκβάλλει, — *if he be Christ*, εἰ οὗτός ἐστιν ὁ Χριστός, — *if David call him Lord*, εἰ καλεῖ, — *if any man have not the spirit of Christ*, εἰ τις πνεῦμα οὐκ ἔχει. It is plain that no principle as to the distinction of the subjunctive and indicative can be derived from this source; and yet here, if anywhere, the Greek distinction would have been followed, if it had been recognized. We find as little help in the language of Shakespeare; thus we have in Macbeth, "If such a one be fit to govern, speak"; "If it be mine, keep it not from me"; "Let me endure your wrath if't be not so"; but just below the last example, "If this, which he avouches, does appear." In Bacon (Maxims of the Law, IX.) we find the following: "If I. S. devise land by the statute of 32 H. VIII., and the heir of the devisor enters and makes a feoffment in fee, and feoffee dieth seized, this descent bindeth." So, "If the land after descend to me, I shall never be remitted." Again (Ibid. XII.), "If a man recovers by erroneous judgment, and hath issue two daughters, and one of them is attainted, the writ of error shall be brought, &c." In turning over the pages of the Spectator, I find fifty instances of the present indicative after *if*, without meeting any of the subjunctive; this can hardly be accidental. The following extract from Macaulay's Essay on Church and State will not disclose very plainly the principle which that writer followed: "If the propagation of religious truth be a principal end of government, as government; if it be the duty of a government to employ for that end its constitutional power; if the constitutional power of governments extends, as it most unquestionably does, to the making of laws for the burning of

heretics ; if burning *be, as it most assuredly is*, a most effectual mode of suppressing opinions, why should we not burn ? If the relation in which government ought to stand to the people *be, as Mr. Gladstone tells us*, a paternal relation, we are irresistibly led to the conclusion that persecution is justifiable." Just below he says : " If a boy *plays* truant at church-time, a task is set him." Again, we find *if it be true* and *if experience shows*, both in the same paragraph. It might be thought that Macaulay was unwilling to use any other subjunctive than *be*, which indeed is the one that most frequently occurs in modern English. Mr. Gladstone writes (*Studies on Homer*, I. p. 18), " If Homer *is* not fully studied in our Universities," and in the next page, " If my estimate of those purposes *be* correct." Again (p. 39), " If it *be* contended," and (p. 80) " If such there *has* been."

These instances are quoted here not by way of criticism, but simply to show the utter want of any principle in English on the subject. It is for scholars to determine whether it is desirable to retain the subjunctive in English ; and whether, if it is to be retained, it is not better to restrict its use to conditions referring to the future, or at least not to allow it to be used beyond the limits which the classical languages so clearly define. The present laxity of usage in respect to it is certainly no honor to our language.

Five hundred and forty-third Meeting.

December 13, 1864. — MONTHLY MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read letters relative to exchanges.

Mr. Ferrel read the following paper.

Note on the Influence of the Tides in causing an Apparent Secular Acceleration of the Moon's Mean Motion.

As the unit of time depends upon the time of the earth's rotation upon its axis, any slight secular change in the time of its rotation, must cause an apparent secular acceleration or retardation of the moon's mean motion. There are two circumstances which may affect the time of the earth's rotation, first, the effect of the attractions of the sun and moon upon the tidal wave retarded by friction, secondly, a gradual decrease of the earth's volume from a loss of heat.

If we conceive the whole surface of the earth to be covered with water, and consider only one section of it perpendicular to the earth's axis, as that of the equator, the effect of the moon is to cause the outline of the fluid to assume the form of an ellipse; and if the tidal wave moved without friction the vertices of this ellipse would be either exactly in the plane of the meridian on which the moon is vertical, or 90° from it, the position depending mainly upon the latitude of the place and the depth of the ocean. In either of these cases the attraction of the moon could not affect the time of the earth's rotation. But as the fluid cannot move over the surface of the nucleus without friction, the position of the vertices of the ellipse, or tidal wave, is a little displaced from the position which they would have without friction, in the former case a little to the east, and in the latter a little to the west. If the resultant of the moon's attraction upon the earth and the counteracting centrifugal force be resolved into radial and tangential forces perpendicular to the planes of the meridians, the latter only can have any tendency to affect the earth's rotation. In the first quadrant east of the meridian upon which the moon is vertical, and its opposite, these tangential forces are towards the west, but in the other two quadrants toward the east. Neglecting quantities of a very small order, these forces in the different quadrants are exactly equal, and hence when the quantity of matter in these quadrants is the same, they can have no tendency to affect the earth's rotation. But we have seen that friction tends to throw the greater part of the tidal wave into the quadrants in which the tangential forces are toward the west. This is also the case when the tide is produced by an oscillatory or rocking motion of the fluid east and west, as in the Atlantic Ocean. Hence there is a preponderance of force toward the west, which causes a slight westward motion of the water, and this motion, by means of friction, transfers this force to the nucleus.

In the third volume of Gould's *Astronomical Journal* I have shown, upon the hypothesis that the outline of the whole tidal wave over the surface of the earth assumes the form of a prolate spheroid, having its vertices displaced 30° by friction, and that the height of the wave above low water is two feet at the equator, that the rotatory motion of the earth at the equator would, by the joint effect of the moon and sun, be retarded about forty-four miles in a century. As the moon moves about $84''$ of arc in its orbit while the earth at the equator moves forty-four miles, the moon's motion from that cause would be apparently

accelerated that amount in a century. But as the observed secular acceleration of the moon as determined from the records of ancient eclipses, is only about 11" per century, and this amount of acceleration seemed, at that time, to be almost exactly accounted for by the real acceleration caused by the secular change in the eccentricity of the earth's orbit, as determined by Laplace, so that he inferred that the length of the day had not changed $\frac{1}{400}$ of a centesimal second since the time of Hipparchus, it was inferred in that paper that, if tidal action had any sensible effect, it must be counteracted by a corresponding contraction of the earth's volume from a gradual loss of heat.

Mayer, in his interesting paper on Celestial Dynamics, has also shown that the attraction of the moon upon the tides retarded by friction, tends to increase the length of the day. He has not, however, attempted to determine the amount of effect produced from any assumed form and position of the tidal wave or aqueous spheroid, but assumes that the retarding pressure must be at least one thousand millions of kilogrammes, and upon this hypothesis he determines that the length of the day would have increased $\frac{1}{16}$ of a second in the last twenty-five hundred years, if the volume of the earth had not changed, and that, if the length of the day has not changed, the radius of the earth must have diminished $4\frac{1}{2}$ metres in the same time. Although Mayer's paper was originally published several years before mine, yet as it has only quite recently been brought before English readers by means of a translation published in the London, Edinburgh, and Dublin Philosophical Magazine, and also in Silliman's Journal, it was entirely unknown to me at the time of the publication of my paper.

At the time of the original publication of Mayer's paper, and also at the time of the publication of my own, Laplace's result of about 11" per century, for the amount of acceleration of the moon's mean motion arising from a secular change of the eccentricity of the earth's orbit, was supposed to be correct, but since that time, it is known, Delaunay and Adams, and also quite recently, Mr. Cayley, by separate and independent investigations, have all obtained less than 6" for the amount of secular acceleration per century, and it is with reference to its bearing upon this new determination that I especially desired to bring forward the subject at this time. This determination, compared with the most reliable determination of the acceleration deduced from the discussion of the recorded observations of ancient eclipses, leaves about 6" to be accounted for by tidal action, or some other *unknown*

cause. Although we cannot determine the exact amount of effect arising from tidal action on account of the uncertainty of the data upon which the computations are based, yet it may be shown that it requires no extravagant and unreasonable hypothesis with regard to the magnitude of the tidal wave, and its retardation by friction, to produce an apparent secular acceleration of $6''$, after making due allowance of the effect of tidal action for counteracting the effect arising from any probable amount of contraction of the earth's volume. If upon the hypothesis of a tidal wave two feet in height, and displaced 30° by friction, the effect of tidal action is to cause an apparent secular acceleration of $84''$, then, since the effect is as the sine of double the angle of displacement, an acceleration of $6''$ would be obtained from a wave of the same height displaced only about 2° , that is, retarded only about eight minutes, by friction. This is upon the hypothesis of no contraction of the earth's volume. According to the investigations of Fourier the loss of heat sustained by the earth by conduction, in a century, would only be sufficient to cause a diminution of the earth's radius to the amount of about seven millimetres, (nearly one third of an inch) the effect of which upon the earth's rotation would be counteracted by an additional retardation by friction of the tidal wave of only about two minutes. The retarding pressure assumed by Mayer corresponds with the effect of a tidal wave two feet high delayed about $1\frac{1}{4}$ hours by friction, but from this assumption he obtains a result which is twenty-six times too great for Fourier's theory of the loss of heat sustained by the earth. But he thinks that the loss of heat by simple conduction taken into account in Fourier's investigations, may be but a small part of the whole amount, and enumerates several other ways in which the earth loses heat. Although the loss of heat may be considerably greater than that which would result from Fourier's theory, yet I think the whole amount of loss cannot be so great as to require any unreasonable amount of retardation of the tidal wave by friction, in order that the effect may be great enough to counteract the effect of the contraction of the earth's volume, and also to retard the time of the earth's rotation enough to cause an apparent secular acceleration of $6''$ per century in the moon's mean motion, and that the hypothesis in my paper of a displacement of 30° , or retardation of two hours, and also Mayer's hypothesis of the amount of tidal pressure, which corresponds to a retardation of about $1\frac{1}{4}$ hours, are both much too great to be reasonable hypotheses, or to be necessary to account for the balance of the

moon's secular acceleration over and above the late determination. We have seen that the hypothesis of a retardation of the tidal wave by friction of only ten minutes is sufficient, according to Fourier's theory, of the loss of heat, and if we suppose the loss to be somewhat greater than this theory requires, it is only necessary to make the hypothesis a very little greater. If $6''$ of the moon's secular acceleration is due to tidal action, then the length of the day has increased about $\frac{1}{140}$ of a second in the last twenty-five hundred years. If the effect of tidal action is insensible, and the late determination of the moon's secular acceleration from theory be received, then we have no way of accounting for the remaining $6''$, and besides we cannot allow that the earth's volume has contracted as much as even Fourier's theory requires. The main point at which we have arrived is, that tidal action is adequate to account for $6''$ of secular acceleration upon a very reasonable and probable hypothesis with regard to the magnitude and retardation of the tidal wave by friction, after making due allowance of the effect for counteracting the effect of a probable contraction of the earth's volume, and that we therefore have no just reason to reject the late determination of secular acceleration arising from a change of the eccentricity of the earth's orbit, because it does not cover the whole amount determined from the observations of ancient eclipses.

Professor Whitney read a paper on the progress of the Geological Survey of California, and presented to the Academy a volume of his report on the Paleontology of that State.

On the motion of Dr. H. R. Storer a committee was appointed, consisting of Professor Rogers, Dr. A. A. Gould, and Professor Agassiz, to consider what action the Academy should take toward promoting the Geological Survey of California and the adjacent territories.

Five hundred and forty-fourth Meeting.

January 10, 1865. — MONTHLY MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read letters relative to exchanges; also a communication from Mr. Otto Struve of the Observatory at Pulkova, announcing the decease of the eminent astronomer his father.

The following communication from Mr. E. W. Morley to Professor A. Hopkins of Williams College, was presented.

I have lately completed the reduction of my observations for the latitude of Williams College Observatory, and thinking you might like to have the result in some form which you can preserve, I transmit the final equations of condition with their solution. You will find the mode of observation fully described in Loomis's Practical Astronomy; briefly it is as follows. The telescope of the transit instrument being adjusted so as to move nearly in the plane of the prime vertical, the star's time of transiting the prime vertical is computed, together with its altitude at that time, and the transit pointed in readiness. The star moves transversely across the field, and is kept in the centre by moving the eyepiece horizontally and the telescope vertically. Its transits over the first ten wires are noted by the chronograph, the instrument is carefully reversed and the transits over the same wires in a reverse order are noted. After passing the meridian the transits over the same wires are noted again, and the instrument reversed as before. This gives forty passages to be noted, and, as a rule, ninety-six readings of the level. As the interval between the east and west passages is from three to five hours, there is but a small probability of getting a complete observation, and the loss of one of the four transits over each wire makes an observation valueless. Unfortunately, during the time I was occupied with the enclosed observations, the weather was so variable that a great proportion of my observations were lost, seven eighths or more I should think. The form of reduction is as follows. Take an observation of α Lyrae, July 19, 1861. Transit over wire (1).

			h.	m.	s.
East vertical, circle South . . .			16	29	3.31
" " North . . .			16	35	2.51
West vertical, circle North . . .			20	28	26.00
" " South . . .			20	34	23.57
W. — E., circle South . . .			4	5	20.26
W. — E., circle North . . .			3	53	23.49
$\frac{1}{4}$ Sum . . .			1	59	40.94
$\frac{1}{4}$ Difference . . .				2	59.19
Cos $\frac{1}{4}$ Sum . . .					9.9378777
Cos $\frac{1}{4}$ Difference . . .					9.9999632
Cotang d (declination) . . .					0.0969342
Cotang λ (latitude) . . .					0.0347751

$$\begin{aligned} \lambda &= 42^{\circ} 42' 30''.73 \\ \text{Correction for level} &+ 3.30 \\ \text{" for azimuth} &- 0.35 \\ \text{" for declination} &+ 1.02 \\ \lambda &42 42 34.75 \end{aligned}$$

The great part of my observations were lost by clouds, which would come up unexpectedly and spoil the labor of four hours, again and again. I have on some nights made as many as twenty observations, involving four hundred passages in the E. V., without getting a single star in the W. V., thus losing all. I can, therefore, rest the latitude of Williams College on only fifty-two observations, but hope these may be enough for present purposes.

Let $\lambda' = (\text{latitude of P. V. instrument} - 42^{\circ} 42' 20'')$.

x be the value of one division of the level, which Mr. Phelps thinks to be near $1''.0$.

Values of $a\lambda' + a'x - b = 0$.

(A.) (From Observation.)

		Δ	Δ^2
1	$\lambda' + 5.39 x - 20.88 =$	$- .92$	.8464
2	$\lambda' + 5.39 x - 19.53 =$	$- 2.27$	5.1529
3	$\lambda' + 5.39 x - 19.53 =$	$- 2.27$	5.1529
4	$\lambda' + 5.39 x - 20.73 =$	$- 1.07$	1.1449
5	$\lambda' + 5.39 x - 21.56 =$	$- .24$	.0576
6	$\lambda' + 5.39 x - 21.09 =$	$- .71$	.5041
7	$\lambda' + 5.39 x - 21.85 =$	$+ .05$	.0025
8	$\lambda' + 5.39 x - 22.27 =$	$+ .47$	.2209
9	$\lambda' + 5.39 x - 23.63 =$	$+ 1.83$	3.3469
10	$\lambda' + 5.39 x - 21.64 =$	$- .16$	.0256
11	$\lambda' + 5.38 x - 21.85 =$	$+ .06$	.0036
12	$\lambda' + 5.38 x - 22.55 =$	$+ .76$	.5776
13	$\lambda' + 5.38 x - 20.73 =$	$- 1.06$	1.1236
14	$\lambda' + 5.38 x - 21.40 =$	$- .39$	.1521
15	$\lambda' + 5.38 x - 21.04 =$	$- .75$	.5625
16	$\lambda' + 5.38 x - 22.06 =$	$+ .27$	.0727
17	$\lambda' + 5.38 x - 22.72 =$	$+ .95$	.9025
18	$\lambda' + 5.38 x - 23.02 =$	$+ 1.23$	1.5129
19	$\lambda' + 5.38 x - 22.63 =$	$+ .84$	.7056
20	$\lambda' + 6.40 x - 23.35 =$	$+ .57$	.3249
21	$\lambda' + 6.40 x - 23.16 =$	$+ .38$	.1444
22	$\lambda' + 6.40 x - 22.07 =$	$- .71$	.5041

		Δ	Δ^2
23	$\lambda' + 6.40 x - 22.92 =$	$+ .14$	.0196
24	$\lambda' + 6.40 x - 23.72 =$	$+ .94$	.8836
25	$\lambda' + 6.40 x - 23.21 =$	$+ .43$	.1849
26	$\lambda' + 6.40 x - 22.52 =$	$- .26$	.0676
27	$\lambda' + 6.40 x - 24.87 =$	$+ 2.09$	4.3681
28	$\lambda' + 6.40 x - 23.32 =$	$+ .54$	.2916
29	$\lambda' + 6.40 x - 23.22 =$	$+ .44$	.1936
30	$\lambda' - 3.30 x - 10.40 =$	$- 1.95$	8.8025
31	$\lambda' - 3.30 x - 11.09 =$	$- 2.26$	5.1136
32	$\lambda' - 3.30 x - 11.26 =$	$- 2.09$	4.3681
33	$\lambda' - 3.30 x - 10.25 =$	$- 3.10$	9.6100
34	$\lambda' - 3.30 x - 11.42 =$	$- 1.93$	3.7249
35	$\lambda' - 3.30 x - 10.95 =$	$- 2.40$	5.7600
36	$\lambda' - 3.30 x - 10.62 =$	$- 2.73$	7.4529
37	$\lambda' - 3.30 x - 11.12 =$	$- 2.23$	4.9729
38	$\lambda' - 3.30 x - 9.75 =$	$- 3.60$	12.9600
39	$\lambda' - 3.30 x - 11.69 =$	$- 2.66$	7.0756
40	$\lambda' - 3.69 x - 14.26 =$	$+ 1.29$	1.6641
41	$\lambda' - 3.69 x - 14.37 =$	$+ 1.40$	1.9600
42	$\lambda' - 3.69 x - 15.72 =$	$+ 2.75$	7.5625
43	$\lambda' - 3.69 x - 15.93 =$	$+ 2.96$	8.7816
44	$\lambda' - 3.69 x - 15.82 =$	$+ 2.85$	8.1225
45	$\lambda' - 3.69 x - 15.34 =$	$+ 2.37$	5.6169
46	$\lambda' - 3.69 x - 15.20 =$	$+ 2.23$	4.9729
47	$\lambda' - 3.69 x - 15.26 =$	$+ 2.29$	5.2441
48	$\lambda' - 3.80 x - 13.40 =$	$+ .53$	.2809
49	$\lambda' - 3.80 x - 15.15 =$	$+ 2.28$	5.1984
50	$\lambda' - 3.80 x - 13.76 =$	$+ .89$	.7921
51	$\lambda' - 3.80 x - 13.95 =$	$+ 1.06$	1.1236
52	$\lambda' - 3.80 x - 13.33 =$	$+ .46$	.2116
(a.) $52 \lambda' + 84.10 x - 944''.11 = 0, \quad \Sigma \Delta^2 = 145.4221.$			

Values of $a' a \lambda' + a'^2 x - a' b = 0.$

(B.)

1	5.39 λ'	$+ 29.05 x - 112.54 = 0$
2	5.39 λ'	$+ 29.05 x - 105.27 = 0$
3	5.39 λ'	$+ 29.05 x - 105.27 = 0$
4	5.39 λ'	$+ 29.05 x - 111.73 = 0$
5	5.39 λ'	$+ 29.05 x - 116.21 = 0$
6	5.39 λ'	$+ 29.05 x - 113.68 = 0$
7	5.39 λ'	$+ 29.05 x - 117.77 = 0$
8	5.39 λ'	$+ 29.05 x - 120.03 = 0$

9	+	5.39 λ'	+	29.05 x	—	130.37	=	0
10	+	5.39 λ'	+	29.05 x	—	116.64	=	0
11	+	5.38 λ'	+	29.05 x	—	117.55	=	0
12	+	5.38 λ'	+	28.94 x	—	121.32	=	0
13	+	5.38 λ'	+	28.94 x	—	111.53	=	0
14	+	5.38 λ'	+	28.94 x	—	115.13	=	0
15	+	5.38 λ'	+	28.94 x	—	113.39	=	0
16	+	5.38 λ'	+	28.94 x	—	118.68	=	0
17	+	5.38 λ'	+	28.94 x	—	122.23	=	0
18	+	5.38 λ'	+	28.94 x	—	123.85	=	0
19	+	5.38 λ'	+	28.94 x	—	121.75	=	0
20	+	6.40 λ'	+	40.96 x	—	149.44	=	0
21	+	6.40 λ'	+	40.96 x	—	148.42	=	0
22	+	6.40 λ'	+	40.96 x	—	141.25	=	0
23	+	6.40 λ'	+	40.96 x	—	146.69	=	0
24	+	6.40 λ'	+	40.96 x	—	151.81	=	0
25	+	6.40 λ'	+	40.96 x	—	148.54	=	0
26	+	6.40 λ'	+	40.96 x	—	144.13	=	0
27	+	6.40 λ'	+	40.96 x	—	159.17	=	0
28	+	6.40 λ'	+	40.96 x	—	149.25	=	0
29	+	6.40 λ'	+	40.96 x	—	148.61	=	0
30	—	3.30 λ'	+	10.89 x	+	37.62	=	0
31	—	3.30 λ'	+	10.89 x	+	36.60	=	0
32	—	3.30 λ'	+	10.89 x	+	37.16	=	0
33	—	3.30 λ'	+	10.89 x	+	33.83	=	0
34	—	3.30 λ'	+	10.89 x	+	37.69	=	0
35	—	3.30 λ'	+	10.89 x	+	36.14	=	0
36	—	3.30 λ'	+	10.89 x	+	35.05	=	0
37	—	3.30 λ'	+	10.89 x	+	36.70	=	0
38	—	3.30 λ'	+	10.89 x	+	32.18	=	0
39	—	3.30 λ'	+	10.89 x	+	38.57	=	0
40	—	3.69 λ'	+	13.62 x	+	52.62	=	0
41	—	3.69 λ'	+	13.62 x	+	54.03	=	0
42	—	3.69 λ'	+	13.62 x	+	58.01	=	0
43	—	3.69 λ'	+	13.62 x	+	58.78	=	0
44	—	3.69 λ'	+	13.62 x	+	58.38	=	0
45	—	3.69 λ'	+	13.62 x	+	56.60	=	0
46	—	3.69 λ'	+	13.62 x	+	56.09	=	0
47	—	3.69 λ'	+	13.62 x	+	56.21	=	0
48	—	3.80 λ'	+	14.44 x	+	50.92	=	0
49	—	3.80 λ'	+	14.44 x	+	57.57	=	0
50	—	3.80 λ'	+	14.44 x	+	52.29	=	0
51	—	3.80 λ'	+	14.44 x	+	53.01	=	0
52	—	3.80 λ'	+	14.44 x	+	50.65	=	0

(b.) $85.10 \lambda' + 1250.65 x - 2625''.55 = 0.$

$$(a) 52.00 \lambda' + 85.10 x - 944''.11 = 0,$$

$$(b) 85.10 \lambda' + 1250.65 x - 2625''.55 = 0,$$

log 1250.65	3.0971358		— 13874.87
log 85.10	1.9299296		+ 2625.55
log (a)	1.1672062		— 11249.32
log 52	1.7160035		1250.65 x
log 52 + log (a)	2.8832095	764.20	— 1250.65 x
			0.0 x
log 944.11	2.9750226		
log (944.11 × a)	4.1422288	13874.87	+ 764.20 λ'
			— 85.10 λ'

Hence, $764''.20 \lambda' + 1250''.65 x - 13874''.87 = 0 + 679''.10 \lambda'$
 $679.10 \lambda' - 11249.32 = 0.$

log 11249''.32	4.0511263		
log 679''.10	2.8319337		
log λ'	1.2191926	λ' = 16''.56	(1)

log 85''.10	1.9299296		
log (85''.10 λ')	3.1491222	1409''.80	— 1409''.80
			2625''.55
log 1215''.75	3.0848452		1215''.75
log 1250''.65 (x)	3.0971358		
log (x)	9.9877064	x = 0''.9721	(2)

$$\Sigma \Delta^2 = 145.4221, \quad \frac{\Sigma \Delta^2}{52} = 2.603$$

log 2.603	0.4156910		
log (2.603) [†]	0.2078455		
log constant	9.8289751	Probable error of single	
log prob. error	0.0368206	observation ± 1''.0885	(3)

log (2.603) [†]	0.20785		
log constant	9.60091		
log mean error	9.80876	Mean error 0''.644	(4)

log $\left(\frac{2 \Sigma \Delta^2}{n}\right)$	0.71650		
log reciprocal	9.28350	Precision .1921	(5)
log √ reciprocal	9.64175	Weight .4383	(6)

$$\frac{\Sigma \Delta^2}{52 - 2} = e^2 = 2.908442$$

$\log e^2$	0.463660	
$\log \chi^2$	0.825686	Table in Coast Survey Report,
$\log \chi^2 e^2$	1.289346	1854, p. 136.*
$\log \chi e$	.644673	
χe	$\pm 4''.412$	Limit by Peirce's Criterion. (7)

$$\begin{aligned} \Sigma a^2 &= 52 & \Sigma a'^2 &= 1250.65 & \Sigma a a' &= 85.10 \\ (\Sigma a a')^2 &= 7242.01 & c &= \Sigma a^2 \cdot \Sigma a'^2 - (\Sigma a a')^2 & &= 57791.79. \end{aligned}$$

	λ'	x
$\log \Sigma a'^2$	3.096118	$\log \Sigma a^2$ 1.71600
$\log c$	4.761868	4.76187
$\log d^2$	8.334250	$\log d'^2$ 6.95413
$\log d$	9.167125	$\log d'$ 8.47706
$\log$ mean error	9.80876	9.80876
$\log$ mean error of result	8.97589	8.28582
Mean error λ' 0''.0946 (8)		Mean error x 0''.0193 (9)

$\log$ constant	0.22807	0.22807
$\log$ prob. error of result	9.20396	8.51389
Probable error λ' 0''.1599 (10)		Prob. error x 0''.0327 (11)

(A) are the fifty-two observations. Each equation should be $= 0$, the quantities in the column Δ are the errors of each observation. The column Δ^2 contains the squares of these errors, and the values of λ' and x are those which make $\Sigma \Delta^2$ (the sum of the squares of the errors) a minimum, and are, therefore, the *most probable* values. (3) gives the quantity 1''.0885, as the probable error of a single observation. (7) gives 4''.41 as the limit, by Peirce's Criterion, for a doubtful observation. (10) gives, as the probable error of the resulting latitude, 0''.16. It is more likely than not that the result is within this amount of the truth. The common tables will show that it is 100 to 1 that my latitude is within 0''.61; 200 to 1 that it is within 0''.67; and 300 to 1 that it is within 0''.78 of the truth.

The prime vertical transit was one hundred feet south of the centre of the dome, which is 1''.0 of arc, which is to be added to my result. α Lyra's place was taken from the English Nautical Almanac. Its declination (d) is 1''.0 different in the American, and 0''.1 less in the

Berlin Jahrbuch. To reduce to either of these authorities, the variation of the declination (δd) must be multiplied into 1.02. When all terms are taken into account, the latitude is

$$\lambda = 42^\circ 42' 20'' + 16''.56 + 1''.0 + 1.02 \delta d \pm 0''.1599,$$

from which for use,

$$\lambda = 42^\circ 42' 37''.56 \quad \text{or,} \quad 42^\circ : 42' : 37''.6 :$$

The value of one division of the level is $0''.972 \pm ''033$.

Five hundred and forty-fifth Meeting.

January 25, 1865.—STATUTE MEETING.

The PRESIDENT in the chair.

The President called the attention of the Academy to the recent decease of two of its members,—Hon. Edward Everett and Mr. W. P. G. Bartlett, of the Resident Fellows.

Professor Henry D. Rogers, of Glasgow, was elected an Associate Fellow in Class II. Section 1.

Mr. Frederick W. Putnam, of Salem, was elected a Resident Fellow in Class II. Section 3.

Five hundred and forty-sixth Meeting.

February 14, 1865.—MONTHLY MEETING.

The PRESIDENT in the chair.

The President called the attention of the Academy to the recent decease of Capt. J. M. Gilliss, an Associate Fellow, and the Director of the National Observatory at Washington.

Mr. Ferrel made the following communication:—

“It was shown in a note read on a former occasion, that if the tidal wave of the ocean is on an average two feet high and displaced two degrees by friction, the effect of the moon’s attraction on the tidal wave must cause an increase of $\frac{1}{140}$ of a second in the length of the day in 2,500 years. From this we may readily determine that the earth’s

rotatory velocity relative to the moon is diminished, in round numbers, the $\frac{1}{28000000}$ part in a century. Now if we suppose the moon to have been originally in a fluid state, it may be demonstrated that the effect of the earth in retarding the moon's rotatory velocity would have been to that of the moon in retarding the earth's rotatory velocity, all other conditions being the same, as the square of the earth's mass is to that of the moon, or as 6,400 to unity, assuming the mass of the moon to be $\frac{1}{80}$ th of that of the earth. But the density of the tidal wave on the earth is much less than the mean density of the earth, and also than the density of the earth's surface, and it moreover occupies only about three fourths of its surface, so that we may assume, if the moon be considered homogeneous or nearly so, that the effect of the earth upon the moon must have been, at least, 20,000 times greater than the effect of the moon upon the earth in diminishing the rotatory velocity. Hence, if we assume that the rotatory velocity of the moon originally was equal to that of the earth, and its tidal wave was displaced two degrees on its surface by friction, it would have lost $\frac{1}{14000}$ part of its rotatory velocity relative to the earth in a century, and consequently, if the amount of tidal displacement could have remained the same, the time of the moon's rotation on its axis would have been reduced to the time of its revolution in its orbit, as we now find it, in 14,000 centuries. But if we suppose friction to diminish with the velocity of rotation relative to the earth, the amount of tidal displacement would diminish in the same ratio, so that if we put v for the rotatory velocity of the moon relative to the earth at any time t , the original velocity being considered unity, we get from the preceding condition,

$$dt = -14,000 \frac{dv}{v}.$$

Putting m for the modulus of common logarithms, this gives

$$T = -\frac{14,000}{m} \log. v',$$

T being the time in which the original rotatory velocity would be reduced to some given velocity v' .

From the preceding equation it is seen that the rotatory velocity of the moon relative to the earth, or to the time of its revolution, could never have been reduced to nothing, however long the moon might have remained in a fluid state, but that it could have been reduced within any assigned limits, however small. Now Laplace has shown, that in order that the mean relative velocity should become nothing,

or in other words, that the time of rotation should be equal to the time of revolution in the case of the solid spheroid, it is not necessary that these motions should have been exactly so at the origin of these motions, which is infinitely improbable, but only that they should have differed by a very small quantity; hence, however much these motions may have differed originally, it was only necessary that the difference should be reduced within certain very small limits by tidal action before solidification, in order that the mean motions should be made to coincide afterwards. The reason of this is readily seen if we consider that at the time of solidification, the longer axis of the spheroid would be almost exactly directed toward the earth, and that at that time, if there was still a very small velocity of rotation relative to the earth remaining, the attraction of the earth upon the excess of matter of the spheroid above that of the inscribed sphere, would bring the vertex back before it would move through a quadrant, and thus prevent a rotation and cause a libratory motion, the period of which, according to Laplace, upon the hypothesis of homogeneity, would be about seven years. But the motion would not only have to be too small to carry the vertex of the spheroid through a quadrant, but too small to carry it so far as to make the libratory motion observable from the earth; for, I believe, no such motion has been observed. If, with Laplace, we assume that the coefficient of the term expressing the libration must be 6,000 centesimal seconds, or more, in order to be observable from the earth, we can readily determine upon this hypothesis that the daily rotatory velocity of the moon, at the time of solidification, must have been reduced, at least, to $\frac{1}{300000}$ part of a revolution. Substituting this for v' in the preceding equation, we get

$$T = \frac{14,000}{m} \log 300,000.$$

This equation gives, in round numbers, T equal to about 175,000 centuries.

We know nothing with regard to the amount of rotatory motion which the moon may have had originally, or with regard to the amount of displacement of the vertex of the spheroid or tidal wave caused by friction, and the preceding hypotheses upon which our results are based have been assumed, not because they are considered the most probable, but merely as a basis for results, from which approximate results can readily be obtained for any other hypotheses.

It is extremely improbable that the two motions should have origi-

nally corresponded with each other, so nearly as Laplace's limits require, by mere accident, but much more probable that they were made to coincide very nearly before solidification, by tidal action, which, I think, has been shown to be an adequate cause for this near coincidence. This idea, so far as I know, was first suggested in my paper, in Gould's *Astronomical Journal*, in the year 1853. The same was also advanced by Helmholtz, in a lecture at Königsberg, in the year 1854.

The following paper was presented :—

Proofs of the Animal Nature of the Cilio-flagellate Infusoria, as based upon Investigations of the Structure and Physiology of one of the Peridiniæ (Peridinium Cypripedium, n. sp.). By PROF. H. JAMES CLARK, A. B., B. S.

Whatever tends to elucidate the doubtful nature of any group of beings which stands undecided (as it were on the dividing line) between sentient and non-sentient things, has an importance, at the present day, which would not have been deemed worthy of very grave consideration before the theories of Spontaneous Generation, and what is sometimes mistakenly called Darwinism, had been revived. The resurgence of these doctrines has given a prominence to the discussion of the character of the lowest, obscure forms of life, simply because, in their extreme simplicity, they hardly seem to rise above a state of inorganic nature, and their vitality is exhibited in such a guise as would readily be mistaken for the operation of exo-endosmotic, inanimate, inorganic forces. Hence the readiness, the eagerness with which the Physicists of the Materialistic school clutch at these "toys" of the older microscopists, hoping therein to find an abundance of argument by which they may prove that rock and flesh do not incompatibly jostle each other whenever they come in contact.

Claiming, and justly too, that these extremes of the inorganic and organic bodies are naturally and incontestably related to each other through their common basis, the simple elements of the chemist, it does not seem possible to the Materialist that their relations should be changed, or dissevered, by the introduction of any modes of existence, however varied or elevated. The Carbon, the Hydrogen, the Nitrogen, and the Oxygen once being established as definite existences, they

always remain C, H, N, and O, no matter under what forms or relations they may be disguised: the various *modes of being* not in the least changing the *fact* of their existence. For instance, they say, the transition from one kind of animate being to another kind is only a graduated change in the mode of existence, or of the manner of an outward expression of the relations of the component *elements* of the organism; certainly not an actual metamorphosis of the nature of these elements. To this assertion there may not possibly be any objection; but if the same explanation were urged for the transition to the Monad from the infinitesimally small, vibrating, inorganic corpuscle of the "Brownian motion," we have not come to that state of knowledge of the forces of nature to so readily accept it as in the former case. Still the growing tendency, among the philosophical chemists, to merge the vital and the inorganic forces into one, would seem to be inevitably preparing us to regard such a transition as identical in kind with that which obtains among the undoubtedly organized bodies, whether animals or plants.

In this state of hesitancy to step across the vanishing line of demarcation, between the animate and the inanimate, we can at least safely venture to give, in general terms, an expression of the relations of the three forms of existence. We may say that it is the *mode of existence* which constitutes the difference between the inorganic and the organic bodies, or between the two forms of organic life, viz. animals and plants. So that every fact enunciated in regard to an animal or plant is the record of a *symbol* of one of the methods of existence, or of the nature of the influences which enter into the life of the being.

From this point of view the study of these insignificants rises to the rank of the highest philosophical inquiry, and the minute wonders of the "microscopist" become the agents in the pursuit after the knowledge of the ways of the Infinite, which one could hardly have the temerity to smile at.

These thoughts have been suggested by the results of some investigations into the thus far doubtful animal nature of the Cilio-flagellate Infusoria, as the Peridiniens and their congeners are designated by Claparède in his, conjointly with Lachman, most recent publications upon the Infusoria.*

* Claparède and Lachman, *Étude sur les Infusoires et les Rhizopodes*, Mem. de l'Ins. Genevois, Tomes V., VI., VII., 1858 - 1861.

In order that the various points of the proof, that the Peridiniens are undoubtedly animals, may be comprehended in systematic sequence, it seems most desirable to present them under separate sections, each devoted to some particular vital function.

Habitat and Form. There is probably no generic difference between the species in question here and those described and figured by Allman, in the third volume of the Journal of Microscopical Science, 1856, and by Claparède in the memoir above referred to; but in their specific relations no doubt they are distinct. This (fig. 1, 2, 3) has an oblique pyriform outline, more than one third longer than its greatest breadth, and hollowed on one side by a broad longitudinal depression (*d*), extending from the narrower end (*P*) to a short distance beyond the broadest part of the body. Not far from the narrower end the so-called flagellum (*f*) is attached, in the middle line of the broad depression, and is so long as to project beyond the end near to which it is situated. As the narrower end (*P*) is always the posterior, and the broader end (*A*) the anterior in the act of swimming, and the relations of the other parts of the body, such as the position of the mouth (*m*), and particularly the trend of the œsophagus (*œ*), correspond to these, the one which precedes should be called the anterior, and the other the posterior end of the body; and as such they will hereafter be designated in this article.

There are two shallow furrows which encircle the body; one (*pf*), rather broad, passes obliquely backwards and around it just behind its middle, and the other (*af*), quite narrow, encircles the broader end just in front of the termination of the broad longitudinal depression above mentioned. The whole of the body posterior to the narrower transverse furrow is clothed with vibratile cilia, but the anterior end is devoid of them, and appears to be covered by a low cap (*pc*) in the form of the segment of a sphere. In the young this cap is so shallow as to be readily overlooked, during the motions of the animal. Close to the posterior end there is a large, clear vesicle (*cv*), which is quite conspicuous, even during the rapid motions of the animal. This is the *contractile vesicle*, which will be described presently. In point of sensitiveness this Peridinium exhibits it in almost as great a degree as Pleuronema and many other timid Infusoria. These are the most evident and striking features, such as readily attract the attention when the body is in motion; and, moreover, they are the chief and characteristic traits of this species. The specific name is derived from the

resemblance in the form of the body to the labellum of one of the Orchidaceæ, viz. *Cypripedium*. It is very common in the fresh-water ditches and slow streams about Cambridge; and in the aquarium congregates in great numbers around decaying matter. It varies from $\frac{1}{80}$ to $\frac{1}{20}$ of an inch in length, but occasionally adults were found $\frac{1}{15}$ of an inch long. It is probable, however, that the latter were in a preparatory state, just before self-division. The color is a uniform light brown, which resides mostly in the derm.

Contractile vesicle. This organ (*cv*) is so conspicuous, in the species before us at least, that one is apt to wonder why it has not been discovered before. The only reasonable excuse for this seeming delinquency would appear to be, that the animal is so incessantly active and so rapid in its motions, that a large amount of patience could hardly compensate for the want of a quiet subject. Fortunately, at the present day, our lenses, even of moderate power, are constructed with such large angles, broad fields, and excellent definition, that the difficulty of keeping the infusorian in sight, and of getting a clear, decided view of its interior, are about done away with. By strewing the glass slide with abundance of indigo, little lagoons are formed here and there, in which, when the specimens are plentiful, there is no difficulty in finding and confining any particular individual, without the necessity of a thin glass covering. In this way the motions of the body are reduced to a simple revolution on its longer axis, with an occasional inversion, end for end. The eye soon gets accustomed to the rhythmical appearance of any particular region as it comes round at each revolution, so that, by a systematic study of each and every feature, a knowledge of the whole organism may be obtained as readily as in most infusoria. The contractile vesicle is invariably situated close to the narrower, or posterior, end of the body, but at a considerable distance from the ventral, dorsal, or lateral surfaces. At the moment just before systole, it has a perfectly globular form (fig. 1, *cv*), and a very sharp, strongly refracting, conspicuous contour, and occupies rather more than the middle third of the transverse diameter of the body at this point. The systole and diastole are as regular in their recurrence as in any of the ciliated infusoria, and as conveniently observed. The systole, in perfectly fresh specimens, occurs with perfect regularity *once in forty seconds*, as numerous and carefully registered observations prove. As in other infusoria, between diastole and systole, the vesicle is more or less irregular in outline, but gradually approximating to a spherical form.

At the moment of systole it rather quickly changes from a broad spheroidal figure to one which is globular, and then contracts suddenly and rapidly until it is nearly invisible. The diastole then follows slowly, and during this it passes from a jagged, rounded outline (fig. 3, *cv*) to a lenticular form (fig. 2), then to a hemispherical shape (fig. 4) with the flattened side next to the posterior end of the body, and finally assuming a spheroidal contour it remains quiet awhile, until the time for the next systole. If the water is not renewed the specimens become unhealthy, which they exhibit by changing their form, and swelling up into an oval, and finally a globular mass. In such a condition the systole of the contractile vesicle oftentimes occurs five or six times in a minute, and will continue at that rate even when the animal is very much flattened out, and until it bursts or falls to pieces. Tincture of opium stops the action of the contractile vesicle almost immediately, even before the rest of the body is sensibly affected by it. The effect is to swell the vesicle to an enormous size, and then, breaking through the posterior end of the animal, it expands to a dimension often exceeding that of the whole body before it bursts.

The mouth (m). That this creature has a mouth might be premised from the manner in which particles of indigo or carmine approach and recede from the body. When the animal is moored by its flagelliform appendage (*f*), and gyrates about it as if on a pivot, these particles of colored food may be seen to pass along the face of the broad longitudinal depression (*d*), and, striking the body just behind its mid-region, glance off in a backward direction. At the point where the indigo strikes may be seen an obliquely longitudinal, ovate opening (*m*), which leads into an elongated funnel-shaped cavity (*æ*). The former is the mouth, and the latter is the œsophagus. The mouth lies altogether within the posterior obliquely transverse furrow (*pf*), and extends from its anterior to its posterior edge, trending diagonally across the axial plane of the body, from right, backwards, toward the left. Its anterior edge (*m*¹) is broad, and from thence it gradually narrows to a sharp angle, which forms the posterior edge. It is so inconspicuous that in all probability it is nearly or altogether closed, except when taking in food; certainly it is not one of the prominent features of the organism, although one of the most important. When the animal is in a sickly condition, and swollen up, the mouth is easily descried, but its relations are not readily made out, because in this state the annular furrows are all obliterated; yet its connection with the œsophagus at

such a time is clearly seen. There are no appendages whatever about, or belonging to the mouth; not even the flagelliform body (*fl*) has anything to do with it, but is attached to the body at a very sensible distance (*fl*¹) behind it. It would seem, therefore, to be dependent upon the simple cilia around it for the transfer of food to its lips. From the mouth the *oesophagus* (*æ*) passes obliquely backwards and toward the dorsal region, at least half-way through the body, and then terminates, rather abruptly, just before the contractile vesicle, but a little to the right side (fig. 3, *æ*) of the axial plane. At the mouth it is widest antero-posteriorly, but suddenly narrowing a little, it afterwards gradually lessens its calibre as it extends into the body, and finally ends as just described. The whole track of this channel is much more readily seen than the mouth. The food is taken in such excessively small particles that its entrance into the mouth cannot be detected with any degree of satisfaction; and a single digestive vacuole (*dv*) requires from twenty minutes to half an hour to form and fill; and although it may be comparatively quite large, even two thirds of its fullest capacity, yet so infinitesimally minute are the particles that even indigo or carmine is not readily seen, although it may be the only kind of food present. Beyond this point, however, these coloring matters become rapidly visible, so that when a vacuole is fully formed, the indigo or carmine is as conspicuous as in any other infusorian. These vacuoles are very large, in fact equalling in size the contractile vesicle; and as they form sometimes pretty far back, they are apt to obscure the latter; without doubt thus causing this vesicle to be mistaken for one of them, since they bear a certain resemblance to it. No anus was detected during these investigations, although the specimens at times were kept well fed.

The locomotive organs. The most prominent among the cilia is the so-called flagellum (*fl*). This, however, is not a single filament, as has usually been asserted, but owing to the manner in which it is used it very naturally appears to be so. Most frequently its compound nature becomes apparent when the numerous cilia of which it is composed divide into two groups (fig. 7, *fl fl*¹), thus simulating a double flagellum.* At other times, after having divided into two groups, they

* Claparède, *loc. cit.*, speaks of frequently noticing that some of the *Ceratiums*, &c. appeared to have a double flagellum. Probably they were a group of cilia divided as here described.

twist about each other in such a way as to resemble a sharply-pointed screw, with a long drawn out double thread. Such is the condition in which this pseudo-flagellum is most frequently seen, and then, with the best magnifying powers, up to five hundred diameters, its compound nature is not easily recognized. But there are times when the whole group of cilia spreads out into a distinct brush, so that each individual cilium may be seen. The base (f^1) of attachment is in the axial plane of the body, a short distance posterior to the mouth (m), and distinctly disconnected from it, as has been already noticed. When not in motion, which seldom occurs, the brush lies along the median furrow (mf) which trends from the mouth to the posterior end of the animal, and in this position it projects for nearly half its length beyond the body. Its most ostensible use would seem to be that of a sort of rudder when the creature is swimming, and as a means of attachment when not progressing. The body may be seen gyrating, and at the same time revolving on its longitudinal axis, for long periods around a point to which the pseudo-flagellum is attached, and upon which it turns like a pivot. It is most frequent that, during this act, a part of the brush separates from the rest, and performs the office of an extra propeller. When the animal is darting and spinning through the water, this appendage projects obliquely from its point of attachment (as in fig. 1), and always following, with the narrower end of the body, in the rear, it seems pretty evidently to be the main agent in the various and sudden tackings to which this infusorian is addicted, and also the axis upon which the body revolves; at least the latter whirls, repeatedly changing as quick as thought from right to left, or *vice versa*, upon an imaginary axis which is oblique to its greatest length, and which exactly corresponds to the trend of the flagelliform appendage when operating in this capacity. Under these conditions the animal shoots along with a compound motion, which might be described as wobbling, or like the action of an eccentric wheel. Apparently in confirmation of this view the annular, obliquely transverse anterior (af) and posterior (pf) furrows trend almost exactly at right angles to this imaginary axis. These two furrows seem, at first sight, to be bands of *vibrating cilia*, and in fact it is in the line of their trend that these cilia are most readily detected, simply because they are rather more crowded along their edges than elsewhere; but an attentive examination reveals their presence all over the body, posterior to the anterior transverse furrow. Between the two furrows (i. e. from af to

pf) they are longer than at the narrower end of the body, and at both points they have a pretty uniform length, moderate extension, and are very delicate, so as not to be easily observed when the body is in motion. At the anterior transverse furrow they appear to be a little longer than elsewhere, and acting more or less in concert, they have the semblance of a wreath disposed along the edge of the low skullcap-like covering (*pc*) of the anterior end.

The cuirass (pc). It is pretty evident that, in the species before us, this is a mere dermal specialization, without any trace of indurated matter which would entitle it to the name of a genuine cuirass. Where vibratile cilia are present no such covering can be said to exist, and as the broad anterior end (*A*) of the body is devoid of them, its skullcap covering is the only portion of the derm where one could expect to find a cuirass. But this it is only in form, since it participates with the rest of the body in the general expansion when an individual is dying. It has, without doubt, a different character from the rest of the skin, for the style of ornamentation is not of the same kind, and, curiously enough too, it is less truly ornamented than in the other regions of the body, amounting to a mere scattered punctuation; whereas over the field where the cilia prevail, these punctuations, which are in reality minute, cylindrical, strongly refracting bodies, standing perpendicular to the surface of the derm, are arranged in perfectly regular rows, which have a different character in the three regions posterior to the pseudo-cuirass. In the space (fig. 5, *D*) between the anterior (*af*) and posterior (*pf*) transverse furrows, the rows trend longitudinally and transversely; in the posterior transverse furrow (*pf*) they have the same arrangement as the last, but they are more closely set together; and in the region behind the latter furrow they trend in decussating lines (*P*), like those in the carapace of *Arcella vulgaris*.

This region is also characterized by being divided longitudinally, on the ventral side, by a furrow (fig. 1, 2, 6, *mf*) which trends in a direct line from the end of the body to the mouth, and gradually widens anteriorly where it joins the annular, transverse furrow (*pf*). At this point of juncture the flagellar appendage arises, and opposite to it the anterior edge of the transverse furrow just mentioned forms an inequilateral angle at the broader margin (*m*¹) of the mouth, so that the right and left halves of this furrow are rendered asymmetrical; a character in perfect accordance with that of many, if not of all the *Peridinæ*.

The nucleus (n) at the period when these observations were made,

viz. early last December, the genital organ invariably laid transverse to the longitudinal axis, and occupied a very large portion of the bulk of the posterior end of the body. Most frequently it had a U-shaped form (fig. 3, *n*), and embraced the contractile vesicle with its two limbs. It was then of a yellowish brown color and perfectly homogeneous. Occasionally it was observed to be divided into three or four masses, which extended toward the region encompassed by the posterior annular furrow. While in the U-shaped form the whole semi-opaque mass was enclosed in a transparent envelope (*ne*). Oftentimes there was to be seen immediately over and close to the dorsal region of the nucleus and directly in the plane of the axis of the body, a minute, clear, vesicular corpuscle (fig. 3, *t*), which seemed to have the character of a "nucleolus" or — as is now becoming the belief, since the investigations of Balbiani and Claparède — a *testicle*.

Reproduction from the egg has not been observed, but transverse division occurred in a number of instances. In the latter case it agrees, in the process, with what Allman, *loc. cit.*, has described, excepting that the resultants (fig. 6, I., II.; fig. 7) are quite different in their proportions from the adults (fig. 1, 2, 3). At the moment of separation the young offshoot (fig. 7) is about two thirds the size of the adult, and is almost as broad as long, and bulges strongly on the ventral side (V), in front of the mouth (*m*). It has a very flat anterior end, and the pseudo-cuirass (*pc*) of this part is represented by an inconspicuous unguiform body. The anterior transverse furrow, on account of its narrowness, hardly attracts attention, except along its ventral edge (*af*), where it is rendered conspicuous by the strong projection of the unguiform cuirass. As in the adult, it is broadest ventrally, but, growing shallower, thins out (*af*¹), going dorsally, to almost nothing. The relations and structure of the various organs, cilia, &c. are the same as in the full-grown individuals; but with progressing growth the proportions of the diverse regions of the body change insensibly, as may be seen by comparing figures 7, 4, and 1, which are respectively representatives of the youngest, middle-aged, and adult individuals.

Description of Figures.

In all the figures the same letters refer to corresponding parts.

- A. The anterior end of the body. P. The posterior end.
- D. The dorsal side. V. The ventral side. R. The right side.
- L. The left side.

- af.* anterior transverse, or annular furrow. *af*¹. dorsal part of *af.*
pf. posterior transverse, or annular furrow.
mf. median, or longitudinal furrow.
d. depression on the ventral side.
cv. contractile vesicle.
m. mouth. *m*¹. anterior edge of *m.*
œ. œsophagus.
dv. digestive vacuoles.
fl. pseudo-flagellum. *fl*¹. base of *fl.*
n. nucleus, or generative organ. *ne.* envelope of *n.* This is the reproductive organ, properly speaking, and *n* is the contents, or reproductive material, the future eggs.
t. nucleolus, or testes.
pc. pseudo-cuirass.
 I., II. The two products of self-division. III. The annular constriction which finally separates I. and II.
 Figs. 1 to 7. *Peridinium Cypripedium*, n. sp.
 Fig. 1. Profile of an adult, seen from the left side. Mag. 500 diam.
 Fig. 2. View of the ventral side of an adult. Mag. 500 diam.
 Fig. 3. Posterior view of an adult; the anterior end in the distance. Mag. 500 diam.
 Fig. 4. A young individual. Mag. 300 diam.
 Fig. 5. An adult gradually dried up. Dorsal view, to show the arrangement of the punctiform ornamentation of the derm. 500 diam.
 Fig. 6. The process of self-division, just half an hour before separation. Ventral view. 200 diam.
 Fig. 7. Profile of I. fig. 6, just at the moment of separation. 200 diam.

The following memoir by Mr. Francis was presented by Professor Treadwell with these introductory remarks:—

About five years ago I called the attention of the Academy to the subject of the strength of cast-iron columns, and presented a paper, which was printed in the Proceedings, containing a short examination of the state of our knowledge upon that subject. It was then thought desirable that a more elaborate examination should be given to it; and a committee was appointed for the purpose. This committee, after two or three consultations, gave over all attention to it, and there the matter has rested, so far as the committee, as a body, were concerned, to this day. One of their members, however, Mr. J. B. Francis of Lowell, whose professional engagements gave him a particular interest in the investigation, finding that nothing would be done by the committee collectively, took up the subject in his own way, and has pursued it at his leisure up to the present time. He has made a most

thorough examination of all the experiments that have been published, or that came within his reach, with the conclusions which have been drawn from them, together with the formulas and rules that have been proposed for practical constructions. Proceeding thus, he has, after a careful and patient examination of the experiments and the reasoning of the several investigations, selected such of the conclusions and formulas as have appeared to him quite trustworthy, and from combining, and, in some cases, modifying these, he has calculated a most elaborate set of tables, by which the architect or practical workman can find a column suited to any structure, and which may be relied upon as safe for all purposes, ordinary, or even extraordinary. I consider the paper thus produced by Mr. Francis as of great value, and believe that it will become a work of the first authority, and of constant reference for the builder.

This paper might, most properly, have been presented to the Academy by Mr. Francis himself, and I think ought to have been thus presented, without my intervention. He has, however, (probably from my having formerly called the attention of the Academy to the subject, and having been chairman of the committee before referred to,) requested me to present the paper for him. I consider myself honored in being thus called upon to communicate a work of such merit to the Academy. Let it be understood, however, that I do not present it as chairman of the committee formerly appointed to examine the subject (this committee have really produced nothing from their charge), but as the sole and private work of Mr. Francis, who alone is entitled to the thanks of the Academy and the community for his most laborious and useful work.

On the Strength of Cast-iron Pillars, with Tables, for the Use of Engineers, Architects, and Builders. By JAMES B. FRANCIS, *Civil Engineer.*

Until the year 1840 the only rule in common use for computing the strength of cast-iron pillars was that given by Tredgold, in his essay on the strength of cast-iron and other metals.* This rule was not founded on experiments made on pillars, or on sound theoretical

* Practical Essay on the Strength of Cast-iron and other Metals. By Thomas Tredgold, London, 1822, and three subsequent editions.

principles; fortunately, however, in its application to cases where great weights were to be supported, the errors were on the safe side. Profound theoretical investigations have been made by Euler and others on the resistance of pillars to *incipient flexure*; the results are valuable, but are not directly available for the wants of practice.

In the year 1840, Mr. Hodgkinson of Manchester, England, presented to the Royal Society his first paper on the strength of cast-iron pillars.* It contains an account of an elaborate series of experiments, on a large scale, made at the expense of William Fairbairn of Manchester, and affording ample data for determining the formulas for computing the breaking weights of solid and hollow cylindrical pillars of cast-iron, and of ordinary dimensions. The formula determined by Hodgkinson from these experiments for hollow cylindrical cast-iron pillars, the lengths being not less than thirty times the external diameters, and the ends being flat, that is to say, with the ends finished in planes perpendicular to the axis, the weight being uniformly distributed on these planes, is

$$W = 99,318 \frac{D^{3.55} - d^{3.55}}{l^{1.7}}, \quad (1)$$

in which

- W = the breaking weight, in pounds.
- D = the external diameter, in inches.
- d = the internal diameter, in inches.
- l = the length in feet.

When the pillars were shorter than thirty external diameters, it was found that they would break with less weight than is given by formula (1). In a long pillar the pressure tends to break it by crushing as well as by flexure, but it fails from flexure with a weight which is too small to sensibly affect it by crushing alone. In a short pillar, on the other hand, the weight required to break it by flexure is so great that the crushing effect becomes sensible, and it fails from the joint effects of the force. It was found by experiment that the effect of the crushing force became sensible when the pillars with flat ends were shorter than thirty times the external diameter, and the formula given by Hodgkinson for the breaking weight of such pillars is

* Experimental Researches on the Strength of Pillars of Cast-iron and other Materials. By Eaton Hodgkinson. Philosophical Transactions of the Royal Society of London, for 1840. Part II.

$$W' = \frac{Wc}{W + \frac{3}{4}c}; \quad (A)$$

in which

W = the breaking weight by formula (1).

W' = the breaking weight for the combined effects of flexure and crushing.

c = the weight which would crush the pillar without flexure, which Hodgkinson finds for Low Moor iron, No. 3, is 109,801 pounds per square inch of section; consequently,

$$c = 109,801 \times \frac{1}{4} \pi (D^2 - d^2).$$

Substituting the value of c in (A), and reducing, we have

$$W' = \frac{86238 (D^2 - d^2) W}{W + 64678 (D^2 - d^2)}.* \quad (2)$$

* In computing the breaking weights of a series of pillars, in order to preserve continuity in the results obtained by formulas (1) and (2), it is necessary at the point where one formula is substituted for the other that we should have

$$W = W';$$

consequently, at this point

$$86238 (D^2 - d^2) = W + 64678 (D^2 - d^2).$$

Substituting the value of W in (1), and reducing, we have

$$l = 2.456 \left(\frac{D^{3.55} - d^{3.55}}{D^2 - d^2} \right)^{\frac{1}{1.7}}$$

For simplicity, confining ourselves to solid pillars, in which $d = 0$, we have, by substituting this value in the last equation,

$$l = 2.456 D^{0.91}$$

l , in this formula, is the length, in feet, of a solid pillar of the diameter D , in inches, for which formulas (1) and (2) give the same breaking weight.

When $D = 0.1 \therefore l = 0.3022$ feet = 3.6264 inches = 36.264 diameters.

" $D = 0.821 \therefore l = 2.0525$ " = 24.6300 " = 30.000 "

" $D = 5.0 \therefore l = 10.6240$ " = 127.4880 " = 25.498 "

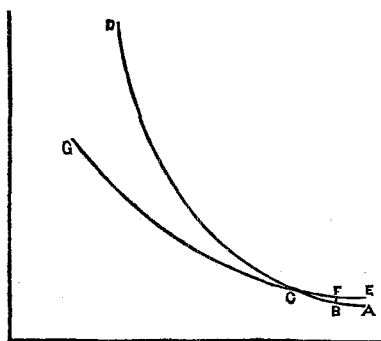
" $D = 10.0 \therefore l = 19.9630$ " = 239.5560 " = 23.956 "

The substitution of formula (2) for formula (1), for pillars of lengths less than 30 diameters, is for the purpose of diminishing the computed breaking weights to conform to the diminished strength of such pillars, on account of the crushing effects of the weights; but in all solid pillars of more than 0.821 inch in diameter there are certain lengths in which the substitution of formula (2) for (1) has the contrary effect; thus, in a pillar 5 inches in diameter, for all lengths between 25.498 diameters and 30 diameters, the breaking weights computed by formula (2) exceed those

Numerous experiments were also made on pillars with the ends rounded, so that the weights bore on the axis. Most of these experiments were made on solid pillars; the hollow ones had hemispherical caps fitted on the ends. It was found that their breaking weight was about one third that of pillars of the same dimensions with flat ends. Some experiments were made on pillars with one end flat and the other end rounded; their breaking weight was about two thirds that of pillars of the same dimensions with both ends flat.

Hodgkinson determined separate formulas for the breaking weights of both solid and hollow cast-iron pillars, with flat ends and also with rounded ends; for practical purposes, however, formulas (1) and (2) are sufficient, recollecting that in a solid pillar $d = 0$, and that the breaking weight of a pillar with rounded ends is one third of that given by formulas (1) and (2). The breaking weight of pillars with rounded ends is so much less than that of pillars with flat ends, that Hodgkinson did not find the crushing effect sensible in pillars with rounded ends when longer than fifteen external diameters; consequently, one third the value of W' , as given by formula (2), will be less than the true breaking weight, when the formula is applied to pillars with rounded ends of lengths between fifteen and thirty diameters. For simplicity, however, I propose to adopt thirty diameters as the limit between formulas (1) and (2), whether the ends are flat or rounded. The errors resulting will be on the side of security, and in ordinary cases, not being large, may be neglected. In a solid pillar with rounded ends, 10 feet long and 8 inches in diameter, the computed breaking weight is about one fourth too small.

computed by formula (1), the maximum excess being about 6 per cent. This is illustrated by the diagram in the margin.



The curve A B C D represents the breaking weights of solid pillars, 5 inches in diameter, by formula (1), and the curve E F C G the same by formula (2), the abscissas being the lengths in diameters, and the ordinates the breaking weights. The curves intersect at the point C, the abscissa of which is 25.498. According to Hodgkinson the breaking weights are represented by A B F C G, the abscissa of the points B and F being 30.

Two experiments were made by Hodgkinson on pillars with the pressure applied at intermediate points, between the centre and circumference. When the pressure was applied parallel to the axis, and half-way between the axis and one side, the breaking weight was about 54 per cent of the breaking weight of a pillar of the same dimensions with the ends rounded, so that the pressure was applied at the axis. In another experiment, the pressure was applied at one eighth of the diameter from one side; in this case, the breaking weight was about 61 per cent of that of a pillar of the same dimensions with rounded ends. In two experiments the pressure was applied in the direction of a diagonal; in both cases the breaking weight was nearly the same as for pillars of the same dimensions with rounded ends. A few experiments were also made on pillars with rounded ends, and other forms than cylindrical. Square pillars had an average breaking weight about 58 per cent greater than cylindrical pillars of diameters equal to the sides of the squares. The square pillars generally failed in the direction of the diagonals. A pillar of the section $\boxplus$, 90.75 inches long, 3 inches across, and the ribs 0.48 inch thick, had a breaking weight 63 per cent greater than the computed breaking weight of a solid cylindrical pillar of the same weight and length. A hollow cylindrical pillar of the same weight and length, and of an external diameter equal to the width of the $\boxplus$, has a computed breaking weight about double that found by experiment for the form $\boxplus$. A pillar of the section **H**, 3 inches in height and 2.5 inches in width, of the same length and nearly the same sectional area as the preceding, had a breaking weight about 2.6 times the computed breaking weight of a solid cylindrical pillar of the same weight and length. A hollow pillar, 3 inches in external diameter, and of the same weight and length, has a computed breaking weight about 19 per cent greater than was found by experiment for the pillar of **H** section.

Several pillars, larger in the middle than at the ends, were tested for the purpose of determining the most economical form; the experiments were not sufficiently numerous or varied to permit any definite conclusions to be drawn. It would appear, however, that in pillars with rounded ends there is a distinct advantage in making them somewhat larger in the middle than at the ends; that is to say, a pillar may be made of this form which would have a breaking weight greater than a cylindrical pillar of the same weight. In pillars with flat ends there is less advantage in departing from the cylindrical form. Hodgkinson

observed that pillars with rounded ends generally broke at the middle only; pillars with flat ends generally broke in three places, at the middle and near each end.

In 1856, Hodgkinson presented a second paper, on the strength of cast-iron pillars, to the Royal Society.* Its special subject is the strength of pillars cast from iron from various parts of Great Britain. The experiments were made at University College, London, with a larger and more powerful apparatus than that which he previously used at Manchester. The pillars tested were longer and larger, and the results reported afford the means of testing, in a very satisfactory manner, the formulas previously determined. The earlier experiments were undertaken for the purpose of determining the laws according to which the breaking weights of pillars depended upon their dimensions. For this purpose, it was necessary to adhere to one description of iron. A Yorkshire iron, Low Moor, No. 3, was selected, which is described as a good iron, not very hard. The formulas were satisfactorily determined for this iron, but there was some risk in applying them to pillars cast from other descriptions of iron, without further experiments. In the second paper, experiments are described on pillars cast from thirteen kinds of iron, — two of them being mixtures.

For the purpose of effecting a systematic comparison between the breaking weights by the experiments of 1856 and the breaking weights computed by the formulas of 1840, the three following tables have been computed, the data being extracted from Hodgkinson's paper of 1856.

TABLE I.

Designation of the Experiments in Hodgkinson's Tables.	Description of the iron from which the pillars were cast.	External diameter.	Internal diameter.	Length.	Breaking weight by formula (1).	Breaking weight by experiment.	Proportional difference.
		In.	In.		Lbs.	Lbs.	
Tab. I. Exp. 1	Low Moor, No. 2	2.513	1.941	10.00	31,334	34,804	+0.1107
" " 2	" "	2.520	1.903	10.00	33,268	39,166	+0.1773
" " 3	" "	3.021	2.354	10.00	58,966	66,259	+0.1237
" " 4	" "	3.035	2.354	10.00	60,627	69,932	+0.1535
" " 5	" "	3.532	2.659	10.00	110,990	110,649	-0.0031
" " 6	" "	3.555	2.693	10.00	112,122	114,479	+0.0210
" " 7	" "	3.804	3.170	9.75	113,149	112,127	-0.0090
Mean proportional difference							+0.0820

* Experimental Researches on the Strength of Pillars of Cast-iron, from various Parts of the Kingdom. By Eaton Hodgkinson. Philosophical Transactions of the Royal Society of London for 1857. Part III.

Table I. gives the dimensions and the breaking weights by formula (1) and by experiment of several long, hollow pillars with flat ends, made of Low Moor iron, No. 2. It will be seen that the breaking weights by experiment vary from about eighteen per cent greater to about one per cent less than the computed breaking weights, the mean being about eight per cent greater.

Table II. gives the dimensions and breaking weights of solid pillars with flat ends, cast from several kinds of iron made in Great Britain ; also the breaking weights of the same pillars, computed by formula (1). It will be observed that the breaking weights by experiment vary from about thirty per cent greater to about fifteen per cent less than the breaking weights computed by the formula, the mean being about nine per cent greater.

TABLE II.

Designation of the Experiments in Hodgkinson's Tables.	Description of the iron from which the pillars were cast.	Diameter.	Length.	Break- ing weight by for- mula (1).	Break- ing weight by ex- peri- ment.	Propor- tional difference.
				In. Ft. Lbs.	Lbs.	
Tab. II. Ex. 11	Low Moor, No. 2	2.553	10.00	55,215	55,973	+0.0137
" " 12	" " "	2.539	10.00	54,148	55,973	+0.0337
" " 13	Blaenavon, No. 3	2.556	10.00	55,446	56,914	+0.0265
" " 14	" " "	2.546	10.00	54,680	57,855	+0.0581
Tab. III. Ex. 1	Old Park, No. 1	2.503	10.00	51,471	66,792	+0.2977
" " 2	" " "	2.526	10.00	53,170	65,381	+0.2297
" " 3	Derwent, No. 1	2.529	10.00	53,394	57,855	+0.0835
" " 4	" " "	2.517	10.00	52,500	66,733	+0.2711
" " 5	Portland, No. 1	2.493	10.00	50,745	59,736	+0.1772
" " 6	" " "	2.527	10.00	53,245	62,559	+0.1749
" " 7	Calder, No. 1	2.490	10.00	50,528	60,677	+0.2009
" " 8	" " "	2.519	10.00	52,649	60,677	+0.1525
" " 9	1st London Mixture, $\frac{1}{2}$ old iron	2.533	10.00	53,695	54,562	+0.0161
" " 10	" " "	2.548	10.00	54,832	59,266	+0.0809
" " 11	Level, No. 1	2.518	10.00	52,575	54,091	+0.0288
" " 12	" " "	2.501	10.00	51,325	56,443	+0.0997
" " 13	Coltress, No. 1	2.516	10.00	52,426	56,443	+0.0766
" " 14	" " "	2.496	10.00	50,962	48,917	-0.0401
" " 15	Carron, No. 1	2.506	10.00	51,691	52,210	+0.0100
" " 16	" " "	2.510	10.00	51,984	53,151	+0.0224
" " 17	Blaenavon, No. 1	2.487	10.00	50,313	48,917	-0.0277
" " 18	" " "	2.499	10.00	51,180	49,858	-0.0258
" " 19	Old Hill, No. 1	2.520	10.00	52,723	44,683	-0.1525
" " 20	" " "	2.523	10.00	52,946	45,154	-0.1472
" " 21	2d London Mixture, $\frac{2}{3}$ old iron	2.511	10.00	52,058	63,499	+0.2198
" " 22	" " "	2.496	10.00	50,962	58,325	+0.1445
" " 23	" " "	1.530	10.00	8,968	11,204	+0.2493
" " 24	" " "	1.541	10.00	9,199	10,868	+0.1814
Mean proportional difference						+0.0877

Table III. gives the results of experiments on solid pillars, cut out of the fragments of the pillars, 10 feet long, used in previous experiments, the results of which are given in Tables I. and II. In the last six ex-

periments in Table III. the pillars were cut out of the fragments formed in the preceding experiments in the same table. The ends of all of them were turned flat and perpendicular to the axis. It will be seen that the breaking weights by experiment vary from about thirty-three per cent greater to about twenty-three per cent less than the breaking weights computed by formulas (1) and (2), the mean being about five per cent greater.

TABLE III.

Designation of the Experiments in Hodgkinson's Tables.	Description of the iron from which the pillars were cast.	Diameter.		Length.	Breaking weight by formula (1) or (2).		Proportional difference.
		In.	Ft.		Lbs.	Lbs.	
Tab. IV. Ex. 1	Old Park, No. 1	2.526	7.50		86,709	100,191	+0.1555
" " 2	" "	2.503	7.50		83,938	95,487	+0.1376
" " 3	Derwent, No. 1	2.517	7.50		85,617	105,365	+0.2307
" " 4	Portland, No. 1	2.527	7.50		86,830	102,543	+0.1810
" " 5	Calder, No. 1	2.490	7.50		82,401	93,135	+0.1303
" " 6	1st Lond. Mixture, $\frac{1}{2}$ old iron	2.548	7.50		89,419	93,605	+0.0468
" " 7	Level, No. 1	2.501	7.50		83,700	98,309	+0.1745
" " 8	Coltness, No. 1	2.516	7.50		85,496	87,019	+0.0178
" " 9	Carron, No. 1	2.506	7.50		84,296	72,437	-0.1407
" " 10	Blaenavon, No. 1	2.500	7.50		83,582	71,967	-0.1390
" " 11	Low Moor, No. 2	2.539	7.50		88,303	89,371	+0.0121
" " 12	Blaenavon, No. 3	2.556	7.50		90,420	85,608	-0.0532
Tab. V. Ex. 1	Derwent, No. 1	2.529	6.25	122,990	112,438		-0.0858
" " 2	1st Lond. Mixture, $\frac{1}{2}$ old iron	2.533	6.25	123,615	114,320		-0.0752
" " 3	Level, No. 1	2.518	6.25	121,284	131,275		+0.0824
" " 4	Old Hill, No. 1	2.523	6.25	122,058	93,622		-0.2330
" " 5	2d Lond. Mixture, $\frac{2}{3}$ old iron	2.511	6.25	120,206	127,432		+0.0601
" " 6	" "	2.496	6.25	113,305	116,672		+0.0297
" " 7	" "	1.530	6.25	19,938	26,527		+0.3305
" " 8	" "	1.530	6.25	19,938	24,763		+0.2420
" " 9	" "	1.541	6.25	20,452	25,939		+0.2683
" " 10	" "	1.528	3.00	63,218	57,384		-0.0923
" " 11	" "	1.544	3.00	65,266	70,555		+0.0810
" " 12	" "	1.527	3.00	63,091	57,856		-0.0830
" " 13	" "	1.531	2.50	77,812	85,138		+0.0941
" " 14	" "	1.530	2.50	77,662	72,907		-0.0612
" " 15	" "	1.515	2.50	75,433	70,555		-0.0647
Mean proportional difference							+0.0462

In his second paper, Hodgkinson also describes a few experiments on square pillars and on pillars with the section of an equilateral triangle; these were compared with cylindrical pillars; two of each pattern were tested, all being cast from the same kind of iron, and were of the same length and nearly the same weights. The relative strengths, reduced to the same weights, were as follows:—

Cylindrical pillar, 100.

Square " 93.

Triangular " 110.

In many of the hollow pillars tested, Hodgkinson found that at the place of fracture the metal was much thicker on one side than on the other ; it would be reasonable to expect that this would weaken them sensibly, but such was not generally the case. Thus, in the third experiment in Table I., the thickness on one side was 0.55 inch, and on the opposite side, 0.17 inch. In the fourth experiment in the same table, the relative thickness on opposite sides was as 2 to 1, nearly. In both of these experiments the breaking weights were above the mean. In the third experiment the direction of the flexure was such that the convex side coincided with the greatest thickness of metal ; in the other experiment the convex side coincided with the least thickness. In most cases, however, the convex side coincided with the greatest thickness.

In experiment 1, Table IX., in Hodgkinson's paper of 1840, the pillar was 7 feet $4\frac{3}{4}$ inches long, external diameter 1.78 inch, internal diameter 1.21 inch, the ends flat and well fitted. The ratio of the thickness on opposite sides of the ring of metal, at the place of fracture, was as 5 to 1. The convexity was on the thickest side. The breaking weight by experiment was 17,840 pounds, which is only about $\frac{1}{15}$ less than the breaking weight computed by formula (1).

The explanation of these remarkable results appears to me to be this: The weight being applied equally on all sides of the pillar, which is supposed to be straight when unloaded, the side having the least metal will be the most compressed ; this will determine the direction of the flexure, so that its convexity will be on the thickest side. When the load is near the breaking weight, the convex side, near the middle, is subject to a tensile force, and the concave side to a crushing force. Hodgkinson found that it required seven or eight times the force per square inch to crush the kind of iron he used that it did to rupture it by a tensile force, and although the sum of the crushing forces, acting on one portion of the horizontal section at the place of fracture, largely exceeds the sum of the tensile forces acting on the other portion of the same section, the difference in the powers of the metal to resist the two forces is so great that, in a long pillar, a much less area of section is required to resist the sum of the crushing forces than to resist the sum of the tensile forces. If the iron from being harder on the thin side is less compressible on that side, or if the weight is not equally distributed on all sides, or if the pillar is not straight when unloaded, the direction of the flexure, when loaded, may be such that the convexity is on the

thin side; in this case the deflection caused by the load will depend on the compression of the thick side; from the greater area subject to compression the amount of the compression, and consequently of the deflection, will be less than if the sides are of equal thickness. In either case, when the inequality in the thickness on opposite sides is not too much, the pillar may support a load as great, or even greater, than if the thickness was equal on all sides.

Hodgkinson determined a new formula for the breaking weight of hollow cylindrical pillars cast from Low Moor iron, No. 2, from the experiments given in his second paper, viz.:—

$$W = 94859 \frac{D^{3.5} - d^{3.5}}{l^{.63}}. \quad (3)$$

Formula (1) was determined from the experiments given in the first paper, which, from their wider range of dimensions, are much better fitted for such an induction than the experiments given in the second paper.

Table IV. contains a comparison between the breaking weights by experiment and by formulas (1) and (3). The pillars were all cast from Low Moor iron, No. 2, and are the same as those given in Table I. It will be seen that the computed breaking weights by formula (3) agree best with the breaking weights by experiment in the smaller pillars, and the computed breaking weights by formula (1) agree best with experiment in the larger pillars. On the whole there appears to be no doubt that formula (1) is the best determined and the safest to adopt in practice.

TABLE IV.

Designation of the Experiments in Hodgkinson's Tables.	External diameter.	Internal diameter.	Length.	Breaking weight by experiment.	Breaking weight by formula (1).	Breaking weight by formula (3).
	In.	In.	Ft.	Lbs.	Lbs.	Lbs.
Tab. I. Exp. 1	2.513	1.941	10.00	34,804	31,334	33,289
" " 2	2.520	1.903	10.00	39,166	33,268	35,350
" " 3	3.021	2.354	10.00	66,259	58,966	62,059
" " 4	3.035	2.354	10.00	69,932	60,627	63,798
" " 5	3.532	2.659	10.00	110,649	110,990	115,971
" " 6	3.555	2.693	10.00	114,479	112,122	117,103
" " 7	3.804	3.170	9.75	112,127	113,149	117,362

In applying the formulas to practice, it is of the greatest importance to determine the proper allowance to be made for possible defects, and to insure complete security against fracture, using no more material than is necessary. In doing this, many things should be considered.

The experiments from which the formulas are deduced were made on pillars of smaller dimensions than those commonly used, and they were very carefully cast from Low Moor iron, No. 3. The strength of iron in small castings is usually greater than in large castings. Low Moor iron has a very high reputation; its transverse strength, however, by Hodgkinson's experiments, appears to be less than that of many other kinds of iron. The different qualities of iron are usually classed as Nos. 1, 2, and 3, differing from each other in the appearance and properties of the material. No. 1 includes the softest and richest irons, those having the largest crystals, and containing generally the most carbon; No. 3, the hardest and densest irons, those having the smallest crystals; No. 2 irons are intermediate between Nos. 1 and 3. No. 3 iron, although the least valuable, is usually the strongest. Castings made from a mixture containing a considerable portion of old metal have usually greater strength than castings from a simple iron (see Table II.) The cheapest irons thus appear to be the most suitable for making pillars.

The experimental pillars, from which the formulas are deduced, were cast in dry sand moulds, and most of them vertically, in order to obtain, as far as possible, uniformity in the texture of the iron. This is generally understood to be the best, as it is the most expensive mode of moulding; but casting vertically does not appear to produce the strongest castings. In the experiments made in 1856 at the Royal Gun Factories at Woolwich, England, on the strength of cast-iron,* fifty-three different kinds of iron were tested; bars were cast 22 inches long, and 2 inches square; in one half of them the moulds were laid horizontally, in the other half vertically; in nearly all cases the bars cast horizontally, when subjected to a transverse strain, had a greater breaking weight than those cast vertically; the average being about 19.5 per cent greater. Founders prefer to cast pillars in moulds laid horizontally, or nearly so, on account of economy; there is, however, much greater liability to imperfections in the castings than when cast vertically.

In the experimental pillars great care appears to have been taken to make them straight; a small variation from a straight line in the axis of a pillar will, in general, weaken it materially; this is a defect, however, which can be readily detected.

* Cast-iron experiments ordered, by the House of Commons, to be printed, July 30, 1858.

In the experiments on pillars with flat ends, much care was taken to have the weight uniformly distributed over the whole area of the metal at the ends; this is not an easy matter to accomplish in so unyielding a material as cast-iron; it can be most readily done by interposing a plate of more ductile metal, such as copper, between the two surfaces of cast-iron. Although this was not done in testing the experimental pillars, there can be no doubt but that they were much better fitted in this respect than can be expected in ordinary practice.

The experimental pillars were tested in a rigid iron frame, which must have secured them from sensible vibration, except for the moments when the weights were applied. In many structures in which cast-iron pillars are used, such as factories, they are pretty constantly subject to vibration; what effect this has in weakening the pillar, it is not easy to estimate; the additional strain tending to produce fracture by lateral flexure must be in some proportion to the amplitude of the vibrations; in pillars of ordinary length and size, such as are commonly used in factories, the amplitudes of the vibrations are very small; although they may be very sensible to the touch, they are usually too small to be detected by the eye; this being the case, it would appear that, ordinarily, the additional strain due to the vibration is very small. It has been a common opinion that long-continued vibration, although very small in amplitude, causes a change in the structure of iron, rendering it more liable to break; of late, however, this notion appears to have been abandoned by those best informed.

In testing the experimental pillars, sufficient weight was applied to break the pillar in a short time, and it is certain that a somewhat less weight would have produced fracture in each case, if applied during a sufficiently long period of time. Fairbairn made some experiments on this point.* He loaded a pillar with 97 per cent of the weight which had previously broken another pillar of the same dimensions; it bore this weight between five and six months, and then broke. In another pillar, loaded with 75 per cent of the weight which had broken another of the same dimensions, at the end of three years its lateral deflection was still increasing slightly; this does not indicate, however, that it would ultimately fail, as we find the deflection of bars of cast-iron subject to a lateral strain increasing for a much longer time, although loaded with from 70 to 96 per cent of the weight which broke another

* Tredgold on Cast-iron. Part II., 4th London edition.

bar of the same dimensions and material. Fairbairn,* referring to his experiments on the progressive deflection of bars of cast-iron, subjected to a transverse strain for a period of about five years, remarks as follows : —

“ Viewing the whole of these experiments in relation to the solution of a problem affecting the laws which regulate the resistance of bodies to continuous strain, it is important to observe how admirably the cohesive powers of matter adapt themselves to circumstances, and with what tenacity they resist forces tending to dis sever and rupture their parts.

“ It is still a question for consideration how far this power extends, and whether or not bodies, when loaded within even $\frac{1}{1000}$ part of their breaking weight, would sustain the load forever, provided that no disturbing cause were present to produce fracture.

“ I am strongly inclined to think that such would be the case, notwithstanding the fact that the whole of the loaded bars exhibit a progressive increase of deflection, which fact I am disposed to attribute to the vibrations continually going on in the building where the bars were fixed, and to those atmospheric changes, such as temperature, oxidation, &c., to which every description of material is subject.”

I think we may safely infer that a pillar, not subject to disturbances, may be loaded with a very large proportion of its breaking weight, say $\frac{9}{10}$, or more, for a time indefinitely long without breaking ; but that a pillar, loaded with a weight a very little less than just sufficient to break it in a short time, will be liable to break within an indefinitely long time ; and that this time will be much shortened if the pillar is subject to vibration.

Pillars in some situations, such as warehouses, are subject to concussions from bodies falling on a floor above ; the effect of this on the pillar would be much weakened by the mass of the floor, and it can scarcely happen when the pillar is otherwise loaded to the full extent it is designed to support.

We have seen that the formulas for the breaking weight are deduced from experiments made on small pillars, very carefully cast from iron of superior quality ; when the same formulas are applied to pillars made of iron of inferior quality for the purpose, and are less carefully cast, it is reasonable to expect that the computed breaking

* On the Application of Cast and Wrought Iron to Building Purposes. By William Fairbairn. London, 1854.

weight will be too great. From what has been stated above, however, it may be inferred that, if the pillars are cast straight and sound, they will, in general, be as strong when made of the cheaper material and by the cheaper mode of casting, as the experimental pillars of Hodgkinson.

We have seen, also, that when the formulas were applied to experimental pillars of somewhat larger dimensions than those from which the formulas were deduced, cast from different kinds of iron, that the actual breaking weights generally exceeded the breaking weights computed by the formulas.

In practice pillars are subject to the effects of vibration and time, which tend to cause them to fail when loaded with less than the computed breaking weights.

What allowance should be made to cover all unfavorable influences, and to afford sufficient surplus strength to insure complete security against failure, is a matter of opinion, and one in which the most experienced and skilful may differ widely.

In 1847, a commission was appointed by the British government to inquire into the application of iron to railway structures. This commission obtained the opinions of the most eminent English engineers and constructors, and in the appendix to their report* they give the following analysis of the evidence relating to cast-iron beams or girders:—

“There appears to be a considerable difference of opinion as to the proportion between the greatest load which a girder should be allowed to bear and the breaking weight. There are two conditions under which the weight may be applied, viz.: 1st, when stationary, as in the case of water-tanks, floors, &c.; 2d, when the weight moves so as to cause concussions and vibrations, as in railway bridges. In girders required for the first case, Mr. Fox and Mr. T. Cubitt consider that the breaking weight should be three times the greatest load; Mr. P. W. Barlow, four times; and Mr. Glynn would not make it less than five times the load.

“In girders for railway bridges, Mr. Brunel states that he allows the load to be $\frac{1}{3}$, or $\frac{2}{5}$, of the breaking weight; but he considers that the rule he adopts for calculating the dimensions of his girders gives more than the usual strength. Mr. Grissell and Mr. Charles May consider

* Report of the Commissioners appointed to inquire into the Application of Iron to Railway Structures. London, 1849.

$\frac{1}{2}$ to be sufficient; Mr. Rastrick, Mr. P. W. Barlow, Mr. R. Stephenson, and Mr. Joseph Cubitt adopt $\frac{1}{2}$; Mr. Hawkshaw prefers $\frac{1}{4}$, except in cases where great care is exercised in the selection of materials and workmanship, when a smaller proportion would suffice; and Mr. Glynn considers that, in structures exposed to concussion and vibration, the ultimate strength of a girder should be 10 times the greatest load."

Defects in material and workmanship are as likely to occur in girders as in pillars, and, with the exception of defective alignment, the defects in girders must be at least as injurious, and require as large an allowance of surplus strength to provide for them as is required to afford the same degree of security in pillars. In determining the proper allowance to be made for security, regard should be had to the consequences of failure. In most of the large modern buildings erected for commercial and industrial purposes, cast-iron pillars are extensively used for supporting the floors, and in many cases the walls of the upper stories are supported in the same manner. The failure of the pillars, in such cases, involves such disastrous consequences, that no economical considerations would warrant the use of pillars of insufficient or doubtful strength.

It is possible, that a single pillar, although ample to support the superincumbent weight, may be broken by a lateral blow; in such an event, the neighboring pillars will usually have a large additional weight thrown upon them, and if they have not considerable surplus strength, the whole structure may be involved in ruin.

These considerations apply to girders as well as pillars, and no doubt they were taken into account by the experienced men whose opinions have been quoted.

It is very obvious that a large allowance of surplus strength must be provided to insure the complete security of a building depending for support on cast-iron pillars; the various considerations which have been offered do not, however, afford any definite data for determining the amount of this allowance. The only safe course is to rely upon the practice and opinions of experienced engineers and constructors. Taking all things into account it appears to me that, in pillars made with ordinary care to support walls and floors, to insure complete security without using more material than is necessary, the greatest load should be about one fifth of the computed breaking weight; and I have adopted this as the rule in computing the following tables.

Whatever allowance of surplus strength may be made for defects, there must be some assurance that the pillars will be cast with, at least, ordinary care. The best guaranty is to employ a founder of known skill and integrity. Some defects can be readily detected by inspection. Pillars having considerable imperfections in the casting should, of course, be rejected. In moulding hollow pillars of ordinary dimensions, the core should be made in one piece; if of more than one piece lengthwise, there is danger of injurious irregularities in the thickness at the junctions of the several parts. In moulding long hollow pillars, it is usual to insert small pieces of iron, called chaplets, to prevent the rising of the core, which, in pillars cast horizontally, is the principal cause of irregularity in the thickness; the chaplets remain, and form part of the pillar; they are frequently the cause of imperfections in the casting, but without using them it appears to be impracticable to make the iron of uniform thickness; a considerable inequality, however, in this respect does not weaken the pillar materially; but it should not be inferred, because Hodgkinson found that pillars in which the thickness on opposite sides varied as much as 3 to 1, were not sensibly weaker than those in which the thickness was uniform, that this irregularity may be disregarded; in Hodgkinson's experiments great care was taken to make sound castings, and also to make the pillars straight, often by turning them in a lathe when not cast straight. Some inequality in thickness must, however, be admitted, if the pillars are cast without chaplets; the extent of the inequality can be ascertained by means of long callipers; in my opinion it should not exceed the proportion of 2 to 1.

Cast-iron pillars are liable to be made crooked from two causes, well known to founders. If the iron is much thicker on one side of a hollow pillar than on the other, the thick side cooling last strains the thin side, and frequently produces a curvature. If the pillar is taken out of the mould while very hot, and laid on supports not furnishing a uniform bearing throughout its length, it is very liable to become bent. It is too much to expect that long pillars will be cast quite straight. I examined ten hollow pillars supporting five floors and the roof of a cotton-mill; I have no doubt they were cast with, at least, ordinary care; I found none of them quite straight. The pillars were about 11.5 feet long, 6 inches in diameter, and about 0.75 inch thick; the average deviation from a straight line in ten feet, which is all that could be conveniently measured, was about 0.03 foot; in other words,

considering the axis to be the arc of a circle, the chord of which was 10 feet, the average versed sine was about 0.03 foot. In one pillar the deviation was about 0.08 foot. These pillars were well-fitted with flat ends, and loaded with less than one tenth of their computed breaking weight. A small part of the observed curvatures must have been due to the load. It may be necessary to admit a curvature when unloaded of $\frac{1}{300}$ of the length as a maximum, which in ten feet would give a versed sine of 0.033 foot.

It is usual to make round pillars a little smaller at the upper end than at the middle, frequently both ends are smaller; this is advantageous in strength with the same weight of iron, and also in appearance; the difference should not much exceed one tenth of the diameter. If smaller at both ends than at the middle, the surface of the pillar should be regularly curved from one end to the other; when so made a small deviation in the axis from a straight line is less observable.

In estimating the amount of the greatest load to which a pillar may be subjected, doubtful points should be taken on the safe side. In warehouses and stores, it would not be safe to take the ordinary load on the floors; they are liable to be packed full of heavy goods. When a warehouse or store is erected for a particular use, it will seldom be safe to estimate the weight due to that particular use; it should be made for the greatest weight due to any use to which such a building may be applied in the ordinary course of business. In modern cotton-mills with wooden floors I have found that the average weight, including the floor itself, the machinery, shafting, stock in process of manufacture, &c., is about 50 pounds per square foot of floor, and a flat roof when loaded with snow is liable to be as heavy. It is not safe, however, to take the average weight, as some pillars will have to support more and some less than the average; I think an addition of one fifth should be made to the average weight for the possible excess. In warehouses and stores, the weights to be provided for are usually much greater than in factories.

In pillars to support railway bridges, or other structures subject to violent concussions or vibrations, a less proportion than one fifth of the breaking weight should be allowed. In experiments on the deflections of railway bridges with a stationary load and with the same load moving at a high velocity, a greater deflection has been observed in the latter case, indicating a corresponding increase of the strain. The increased strain will, however, be principally felt in the girders, and

will be only partially communicated to the pillars or other supports of the bridge.

Formulas (1) and (2) give the breaking weights of cast-iron pillars with the ends carefully fitted, so that the weight will be uniformly distributed on all sides; in ordinary constructions the ends are frequently unfinished, the inequalities in the bearing surfaces causing the weight to rest on a few points of the ends; the breaking weight of the pillar, in such case, cannot safely be taken as greater than that of a pillar with rounded ends, which, as we have seen, is about one third that of a pillar with flat ends. In cotton-mills, and many other structures largely supported by cast-iron pillars, the ends of the pillars are frequently turned, corresponding in this respect to the experimental pillars with flat ends; it would generally not be safe, however, to assume that they are as perfectly fitted as they were in the experiments; when put in place it must frequently happen that they will be canted a little, causing the bearing to fall on one edge; it will, accordingly, not be safe to assume that formulas (1) and (2) apply to this case without modification. If the ends are as perfectly fitted as they were in the experimental pillars, the breaking weight would be three times as great as in pillars with rounded ends; if one end is well fitted and the other end rounded, the breaking weight is twice that of pillars with both ends rounded; it would seem, therefore, that we may safely assume that, when pillars with flat ends are fitted and put up with ordinary care, they will support one and a half times as much as pillars with rounded ends, or, what is equivalent, one half the weight of pillars fitted and put up as perfectly as in the experiments.

The following tables have been computed by formulas (1) and (2), taking one third of the breaking weight as given by them for the breaking weight of a pillar with rounded ends, and one fifth of this last breaking weight as the safe weight for a pillar with rounded ends, or, what we assume to be equivalent, with the ends not turned. The safe weights for the other cases can be easily deduced from the same tables, as will be seen in the explanation of their use.

Tredgold's table was generally relied upon by constructors, until the publication of Hodgkinson's experiments. The same table reappears in the fourth edition of Tredgold's work, edited by Hodgkinson, with the note that "This table has no solid basis." As no other table is given, however, it is probable that its use has been continued by many persons not accustomed to such computations. Table V. contains a

comparison of the safe weights, in tons of 2,000 pounds, which several solid pillars will support according to Tredgold's table, and according to Hodgkinson's formulas (1) and (2), taking one fifth of the breaking weight of a pillar with rounded ends as the safe weight. It will be seen that in the smaller pillars Tredgold gives a larger weight than according to Hodgkinson, while in the larger pillars Tredgold's weight is less than Hodgkinson's. It is remarkable; however, considering the origin of Tredgold's table, that they should differ so little.

TABLE V.

Diameter of the pillar.	Safe weight a pillar 8 feet long will support,		Safe weight a pillar 10 feet long will support,		Safe weight a pillar 12 feet long will support,	
	According to Tredgold.	According to Hodgkinson.	According to Tredgold.	According to Hodgkinson.	According to Tredgold.	According to Hodgkinson.
In.						
2.0	2.74	1.13	2.24	0.77	1.79	0.57
2.5	5.10	2.50	4.31	1.71	3.64	1.25
3.0	8.12	4.77	7.17	3.26	6.22	2.39
3.5	11.98	8.38	10.70	5.64	9.63	4.14
4.0	16.13	12.76	14.90	9.06	13.55	6.65
4.5	22.32	18.36	19.82	13.95	18.31	10.10
5.0	26.82	25.28	25.31	19.46	23.91	15.38
6.0	32.09	43.31	30.80	34.15	29.40	27.46
7.0	55.38	67.26	53.70	54.20	51.74	44.30
8.0	72.18	97.36	70.50	79.99	68.54	66.36
9.0	93.63	133.73	91.84	111.78	89.77	94.02
10.0	116.31	176.41	114.52	149.73	112.39	127.53

In the Journal of the Franklin Institute of Pennsylvania, commencing in the number for November, 1861, there have appeared a large number of interesting and useful tables relating to the strength of pillars of various materials, computed by the formulas of Hodgkinson, Tredgold, and others, by W. Bryson, Civ. Eng. These tables mostly give the breaking weights of solid pillars. Similar tables of more limited extent may be found in other works, but none of them appear to meet the wants of the practical man.

Use of the Following Tables.

The weights are given in lawful tons of the State of Massachusetts, viz. of 2,000 pounds avoirdupois, and are the weights which can be borne with safety by cylindrical cast-iron pillars made with ordinary care and with rounded ends, or what are assumed for this purpose to be equivalent, with ends not finished in planes at right angles to the axis, and the weight not uniformly distributed over the whole area of the ends.

Rule for Cylindrical Cast-iron Pillars.

For practical purposes we may divide the use of cylindrical cast-iron pillars into three cases:—

1. Pillars with rounded ends, or put up as they come from the founder, or with only the prominent irregularities at the ends chipped off, or however the ends may be, if the weight is very unequally distributed over their surfaces, or if unequal settlements may be apprehended. When the designer of the pillars has no control over the execution of the work or any guaranty that his directions will be minutely followed, his only safe course will be to consider them in this case. The weights given in the tables are the safe weights the pillars will support in this case.

2. Pillars with the ends turned in a lathe, to planes at right angles to the axes, and put up with ordinary care, so that the weight will be distributed over the whole area of the ends; the pillars being made and put up under the eye of the person responsible for their sufficiency, or with such other guaranty for faithful workmanship as may be satisfactory to him. In this case, it is assumed that the safe weight is one and a half times that for a pillar with rounded ends, and may be found from the tables by adding one half to the tabular weight.

3. Pillars with the ends finished, and put up with the degree of perfection attained in Hodgkinson's experiments on pillars with flat ends. The safe weight in this case is three times that given in the tables.

Note. The tables give the dimensions of several pillars of nearly equal strengths, from which, of course, may be selected the pillar deemed most suitable for the intended purpose. If the pillar is made a little smaller at one or both ends than in the middle, its strength will be nearly the same as that of a cylindrical pillar of the same length and of a diameter equal to its middle diameter.

Example. Required the dimensions of a pillar 12 feet long, the greatest load to be supported by it being 25 tons.

If in the first case, we find at the page of the table headed, "Cylindrical pillars of cast-iron 12 feet long," taking the tabular weights, nearest to, but not less than, 25 tons, that if solid, the pillar must be 6 inches in diameter; if $\frac{3}{4}$ inch thick, $7\frac{1}{2}$ inches in diameter; if 1 inch thick, $6\frac{3}{4}$ inches in diameter, &c.

If in the second case, take $\frac{2}{3}$ of 25 tons, which is 16.67 tons; proceeding in the same manner as in the first case, we find that, if solid,

the pillar must be $5\frac{1}{4}$ inches in diameter ; if $\frac{3}{4}$ inch thick, $6\frac{1}{4}$ inches in diameter ; if 1 inch thick, $5\frac{3}{4}$ inches in diameter, &c.

If in the third case, take $\frac{1}{3}$ of 25 tons, which is 8.33 tons; proceeding in the same manner, we find that, if solid, the pillar must be $4\frac{1}{2}$ inches in diameter ; if $\frac{3}{4}$ inch thick, $4\frac{3}{4}$ inches in diameter ; if 1 inch thick, $4\frac{1}{2}$ inches in diameter, &c.

In the absence of tables specially computed for the purpose, the use of the following tables may be extended to rectangular pillars of cast-iron, and to pillars both cylindrical and rectangular of some other materials.

Rule for Solid Square Cast-iron Pillars.

Calling the strength of a cylindrical pillar 100, the strength of a prismatic pillar of square section, whose side is equal to the diameter of the cylindrical pillar, according to different authorities, is as follows : —

According to Tredgold, when the distance of the direction of the force from the axis of the pillar is $\frac{1}{3}$ of the diameter	146
Also, according to Tredgold, when the neutral axis is at or near the axis of the pillar	170
According to three experiments on square cast-iron pillars with rounded ends, given in Table III. of Hodgkinson's paper in Phil. Trans. for 1840	158
According to experiments on two square cast-iron pillars and two cylindrical cast-iron pillars, all with flat ends, given in the appendix to Hodgkinson's paper in Phil. Trans. for 1858	143

Assuming the proportion to be as 100 to 150, the safe weight which can be supported by a solid square cast-iron pillar is given by the following rule : —

Determine the weight for a cylindrical cast-iron pillar, of a diameter equal to the side of the square pillar, by the preceding rule for the particular case ; add one half to this weight, the sum will be the weight for the square pillar.

Rule for Solid Prismatic Cast-iron Pillars, whose Section is a Rectangular Parallelogram.

Find, by the rule for square cast-iron pillars, the weight for a square pillar whose side is equal to the small side of the parallelogram ; multiply this weight by the long side of the parallelogram, and divide the product by the small side ; the quotient is the safe weight required.

Rule for Hollow Rectangular Pillars.

Find by the preceding rules the weights for solid pillars of the outside and inside dimensions of the hollow pillar; subtract one from the other; the difference will be the safe weight for the hollow pillar.

Rule for Solid Cylindrical Wrought-iron Pillars.

According to Hodgkinson, calling the strength of a cast-iron pillar 1000, the strength of a wrought-iron pillar of the same dimensions is 1745. Then to find the safe weight for a solid cylindrical wrought-iron pillar, find, by the preceding rules for cylindrical cast-iron pillars, the weight for a cast-iron pillar of the same dimensions; multiply this weight by 1.745; the product will be the safe weight for the wrought-iron pillar.

Note. This rule must be confined to pillars very long in proportion to their diameters; say, in pillars with flat ends, to lengths of not less than 60 diameters. Hodgkinson's experiments indicate that wrought-iron pillars with flat ends, of lengths equal to 30 diameters, are only about one tenth stronger than cast-iron pillars of the same dimensions. In a single experiment on a wrought-iron pillar with flat ends, of a length equal to about 15 diameters, the strength was nearly 40 per cent less than that of a like pillar of cast-iron. This great difference in the relative strengths of cast and wrought-iron pillars of different lengths in proportion to the diameters, arises from the greater strength of wrought-iron to resist a tensile force, and its less strength to resist a crushing force, the strength of short pillars depending mainly on the power of the material to resist the latter force.*

Rule for Solid Square Wrought-iron Pillars.

Find by the preceding rule the weight for a solid cylindrical pillar of wrought iron, whose diameter is equal to the side of the square pillar; add one half to this weight, the sum will be the safe weight for the square pillar. The length of the pillars to which this rule applies is subject to the same limitations as in the preceding rule.

* Strength of cast-iron (Low Moor, No. 3) to resist a crushing force 109,801 pounds per square inch; to resist a tensile force 14,535 pounds per square inch (Hodgkinson). Then crushing strength to tensile strength as 7.55 to 1.

Strength of wrought-iron to resist a crushing force 36,000 to 40,000 pounds per square inch; to resist a tensile force 60,000 to 70,000 pounds per square inch (Rankine). Then crushing strength to tensile strength about as 1 to 1.7.

Rule for Solid Cylindrical Cast-steel Pillars.

According to Hodgkinson, calling the strength of a cast-iron pillar 1000, the strength of a cast-steel pillar, not hardened, of the same dimensions, is 2518. Then to find the safe weight for a solid cylindrical cast-steel pillar, find, by the preceding rules for cylindrical cast-iron pillars, the weight for a cast-iron pillar of the same dimensions, multiply this weight by 2.518, the product will be the safe weight for the cast-steel pillar.

*Rule for Solid Cylindrical Pillars of Dantzic Oak and Red Deal.**

According to Hodgkinson, calling the strength of a cast-iron pillar 1000, the strength of a pillar of the same dimensions of Dantzic Oak is 108.8 and of Red Deal 78.5. Then, to find the safe weight for solid cylindrical pillars of these materials, find, by the preceding rules for cylindrical pillars of cast-iron, the weight for a cast-iron pillar of the same dimensions; if for Dantzic Oak, divide this weight by nine, if for Red Deal, by thirteen, the quotient will be the safe weight for the wooden pillar.

Rule for Solid Square Pillars of Dantzic Oak and Red Deal.

Find the weight for a cylindrical pillar of a diameter equal to the side of the square pillar by the next preceding rule; add one half to this weight, the sum will be the safe weight for the square pillar.

* Barlow's formula for the breaking weight of a beam supported at each end and loaded in the middle is, $S = \frac{Wl}{4ad^2}$; in which S is a constant to be determined by experiment, W the breaking weight, l the length between the points of support, a the breadth and d the depth of the beam, the dimensions being all in inches.

For Dantzic oak (so called in England from the place of shipment), from experiments by Barlow and Moore	S = 1518
For American White Oak (<i>Quercus alba</i>), from experiments by Nelson	S = 1699
For Red Deal (<i>Pinus sylvestris</i> , Scotch Fir, Riga Fir), from ex- periments by Barlow	S = 1165
For American White Pine (<i>Pinus strobus</i>), from experiments by Nelson	S = 1456

The values of S do not necessarily give the relative strengths of different woods when used for pillars; they, however, afford some indication, and we may conclude, from the values quoted, that we may safely adopt the rule for pillars of Dantzic Oak for pillars of American White Oak, and the rule for pillars of Red Deal for pillars of American White Pine.

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in								
Diameter of Pillar outside.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	$1\frac{1}{8}$ Inch.
Inches.								
2	1.13	0.92	1.03					
$2\frac{1}{4}$	1.72	1.31	1.50	1.62				
$2\frac{1}{2}$	2.50	1.79	2.09	2.28	2.40			
$2\frac{3}{4}$	3.50	2.37	2.80	3.09	3.29	3.41		
3	4.77	3.05	3.64	4.07	4.36	4.56	4.67	
$3\frac{1}{4}$	6.61	3.62	4.43	5.07	5.57	5.94	6.21	6.39
$3\frac{1}{2}$	8.38	4.30	5.30	6.12	6.77	7.28	7.66	7.94
$3\frac{3}{4}$	10.42	5.03	6.24	7.25	8.08	8.74	9.26	9.66
4	12.76	5.79	7.24	8.46	9.48	10.32	11.00	11.53
$4\frac{1}{4}$	15.40	6.60	8.28	9.73	10.97	12.00	12.86	13.55
$4\frac{1}{2}$	18.36	7.44	9.38	11.07	12.53	13.78	14.83	15.71
$4\frac{3}{4}$	21.65	8.31	10.51	12.46	14.17	15.65	16.91	17.98
5	25.28	9.20	11.69	13.91	15.87	17.59	19.09	20.37
$5\frac{1}{4}$	29.25	10.13	12.90	15.40	17.63	19.61	21.35	22.86
$5\frac{1}{2}$	33.57	11.07	14.15	16.94	19.45	21.69	23.69	25.45
$5\frac{3}{4}$	38.26	12.04	15.42	18.51	21.31	23.84	26.10	28.12
6	43.31	13.02	16.72	20.12	23.22	26.03	28.58	30.86
$6\frac{1}{4}$	48.73	14.02	18.04	21.75	25.16	28.28	31.11	33.67
$6\frac{1}{2}$	54.53	15.04	19.39	23.42	27.14	30.56	33.70	36.55
$6\frac{3}{4}$	60.70	16.07	20.75	25.11	29.15	32.89	36.33	39.48
7	67.26	17.11	22.13	26.82	31.19	35.25	39.01	42.46
$7\frac{1}{4}$	74.20	18.16	23.52	28.55	33.26	37.64	41.72	45.49
$7\frac{1}{2}$	81.53	19.22	24.93	30.30	35.35	40.06	44.47	48.56
$7\frac{3}{4}$	89.25	20.29	26.35	32.07	37.45	42.51	47.24	51.66
8	97.36	21.36	27.78	33.85	39.58	44.98	50.05	54.80
$8\frac{1}{4}$	105.87	22.45	29.22	35.64	41.72	47.46	52.88	57.96
$8\frac{1}{2}$	114.76	23.53	30.66	37.44	43.88	49.97	55.73	61.16
$8\frac{3}{4}$	124.05	24.63	32.12	39.26	46.05	52.49	58.60	64.37
9	133.73	25.73	33.58	41.08	48.23	55.03	61.49	67.61
$9\frac{1}{4}$	143.81	26.83	35.05	42.91	50.42	57.58	64.39	70.86
$9\frac{1}{2}$	154.28	27.95	36.52	44.75	52.62	60.14	67.31	74.13
$9\frac{3}{4}$	165.15	29.05	38.00	46.59	54.83	62.71	70.24	77.42
10	176.41	30.16	39.48	48.44	57.04	65.28	73.18	80.72

Cast-iron 8 feet long.

if solid, as in the first column, or if hollow, as in the succeed- the respective headings.							
Diameter of Pillar outside.	1 $\frac{1}{4}$ Inch.	1 $\frac{3}{8}$ Inch.	1 $\frac{1}{2}$ Inch.	1 $\frac{5}{8}$ Inch.	1 $\frac{3}{4}$ Inch.	1 $\frac{7}{8}$ Inch.	2 Inch.
Inches.							
2							
2 $\frac{1}{4}$							
2 $\frac{1}{2}$							
2 $\frac{3}{4}$							
3							
3 $\frac{1}{4}$							
3 $\frac{1}{2}$	8.13						
3 $\frac{3}{4}$	9.95	10.15					
4	11.94	12.25	12.46				
4 $\frac{1}{4}$	14.10	14.53	14.84	15.08			
4 $\frac{1}{2}$	16.42	16.99	17.43	17.76	18.01		
4 $\frac{3}{4}$	18.87	19.60	20.19	20.65	21.00	21.26	
5	21.46	22.37	23.12	23.73	24.21	24.58	24.86
5 $\frac{1}{4}$	24.17	25.28	26.21	26.98	27.61	28.11	28.50
5 $\frac{1}{2}$	26.98	28.31	29.44	30.40	31.19	31.85	32.37
5 $\frac{3}{4}$	29.89	31.45	32.80	33.96	34.94	35.76	36.44
6	32.90	34.70	36.28	37.65	38.84	39.85	40.69
6 $\frac{1}{4}$	35.98	38.04	39.86	41.47	42.87	44.08	45.12
6 $\frac{1}{2}$	39.13	41.46	43.55	45.40	47.03	48.46	49.70
6 $\frac{3}{4}$	42.36	44.96	47.32	49.43	51.30	52.97	54.43
7	45.64	48.53	51.17	53.54	55.68	57.59	59.28
7 $\frac{1}{4}$	48.97	52.16	55.09	57.75	60.15	62.32	64.26
7 $\frac{1}{2}$	52.35	55.85	59.07	62.02	64.70	67.14	69.34
7 $\frac{3}{4}$	55.77	59.59	63.11	66.36	69.33	72.05	74.52
8	59.24	63.37	67.21	70.76	74.03	77.04	79.78
8 $\frac{1}{4}$	62.73	67.19	71.35	75.21	78.79	82.09	85.13
8 $\frac{1}{2}$	66.26	71.05	75.54	79.72	83.61	87.21	90.54
8 $\frac{3}{4}$	69.82	74.95	79.76	84.27	88.47	92.39	96.02
9	73.40	78.87	84.01	88.85	93.38	97.62	101.56
9 $\frac{1}{4}$	77.00	82.81	88.30	93.47	98.33	102.89	107.16
9 $\frac{1}{2}$	80.63	86.78	92.61	98.12	103.32	108.21	112.79
9 $\frac{3}{4}$	84.27	90.77	96.95	102.81	108.34	113.56	118.47
10	87.92	94.78	101.31	107.51	113.39	118.94	124.19

Cylindrical Pillars of

Safe weight, in tons of 2,000 pounds, which they can support,
ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside. Inches.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	$1\frac{1}{8}$ Inch.
2	0.92	0.75	0.85					
$2\frac{1}{4}$	1.41	1.07	1.23	1.33				
$2\frac{1}{2}$	2.04	1.47	1.71	1.87	1.96			
$2\frac{3}{4}$	2.87	1.94	2.29	2.53	2.69	2.79		
3	3.90	2.50	2.98	3.33	3.57	3.73	3.82	
$3\frac{1}{4}$	5.19	3.14	3.78	4.26	4.61	4.85	5.01	5.11
$3\frac{1}{2}$	6.75	3.88	4.70	5.34	5.82	6.17	6.41	6.57
$3\frac{3}{4}$	8.95	4.89	5.44	6.31	7.01	7.57	8.01	8.34
4	11.00	5.08	6.34	7.39	8.27	8.98	9.56	10.01
$4\frac{1}{4}$	13.32	5.82	7.29	8.55	9.61	10.50	11.23	11.81
$4\frac{1}{2}$	15.94	6.59	8.29	9.77	11.03	12.11	13.01	13.75
$4\frac{3}{4}$	18.86	7.39	9.34	11.05	12.53	13.81	14.91	15.82
5	22.10	8.22	10.43	12.38	14.10	15.60	16.90	18.00
$5\frac{1}{4}$	25.66	9.08	11.55	13.77	15.73	17.47	18.98	20.29
$5\frac{1}{2}$	29.55	9.97	12.72	15.20	17.42	19.40	21.15	22.68
$5\frac{3}{4}$	33.78	10.88	13.91	16.67	19.16	21.40	23.39	25.16
6	38.36	11.81	15.14	18.19	20.95	23.46	25.71	27.72
$6\frac{1}{4}$	43.30	12.76	16.39	19.73	22.79	25.57	28.09	30.36
$6\frac{1}{2}$	48.59	13.73	17.67	21.32	24.67	27.74	30.54	33.07
$6\frac{3}{4}$	54.25	14.71	18.97	22.93	26.58	29.95	33.03	35.85
7	60.28	15.71	20.29	24.56	28.53	32.20	35.58	38.68
$7\frac{1}{4}$	66.68	16.72	21.63	26.23	30.51	34.49	38.17	41.57
$7\frac{1}{2}$	73.46	17.74	22.99	27.91	32.51	36.81	40.80	44.50
$7\frac{3}{4}$	80.62	18.78	24.36	29.62	34.55	39.16	43.47	47.48
8	88.16	19.83	25.75	31.34	36.60	41.55	46.18	50.50
$8\frac{1}{4}$	96.09	20.88	27.15	33.08	38.68	43.95	48.91	53.56
$8\frac{1}{2}$	104.40	21.94	28.55	34.83	40.77	46.38	51.67	56.65
$8\frac{3}{4}$	113.11	23.01	29.97	36.60	42.88	48.84	54.46	59.77
9	122.20	24.08	31.40	38.38	45.01	51.31	57.28	62.92
$9\frac{1}{4}$	131.68	25.17	32.84	40.17	47.15	53.80	60.11	66.09
$9\frac{1}{2}$	141.56	26.25	34.29	41.97	49.31	56.30	62.96	69.29
$9\frac{3}{4}$	151.83	27.33	35.74	43.78	51.48	58.82	65.83	72.50
10	162.50	28.44	37.20	45.60	53.65	61.36	68.72	75.74

Cast-iron 9 feet long.

if solid, as in the first column, or if hollow, as in the succeed- the respective headings.							
Diameter of Pillar outside.	1 $\frac{1}{4}$ Inch.	1 $\frac{3}{8}$ Inch.	1 $\frac{1}{2}$ Inch.	1 $\frac{5}{8}$ Inch.	1 $\frac{3}{4}$ Inch.	1 $\frac{7}{8}$ Inch.	2 Inch.
Inches.							
2							
2 $\frac{1}{4}$							
2 $\frac{1}{2}$							
2 $\frac{3}{4}$							
3							
3 $\frac{1}{4}$							
3 $\frac{1}{2}$	6.67						
3 $\frac{3}{4}$	8.57	8.74					
4	10.34	10.59	10.77				
4 $\frac{1}{4}$	12.27	12.62	12.88	13.07			
4 $\frac{1}{2}$	14.35	14.83	15.19	15.47	15.66		
4 $\frac{3}{4}$	16.58	17.19	17.68	18.06	18.35	18.56	
5	18.94	19.71	20.34	20.85	21.25	21.55	21.77
5 $\frac{1}{4}$	21.42	22.37	23.16	23.81	24.33	24.75	25.07
5 $\frac{1}{2}$	24.01	25.15	26.12	26.93	27.61	28.15	28.58
5 $\frac{3}{4}$	26.71	28.06	29.22	30.21	31.05	31.74	32.30
6	29.51	31.08	32.45	33.63	34.65	35.50	36.22
6 $\frac{1}{4}$	32.39	34.20	35.79	37.18	38.39	39.43	40.31
6 $\frac{1}{2}$	35.36	37.41	39.24	40.86	42.27	43.50	44.57
6 $\frac{3}{4}$	38.40	40.71	42.79	44.64	46.28	47.72	48.98
7	41.52	44.09	46.43	48.52	50.40	52.06	53.53
7 $\frac{1}{4}$	44.69	47.54	50.15	52.50	54.62	56.53	58.22
7 $\frac{1}{2}$	47.92	51.06	53.94	56.57	58.95	61.10	63.03
7 $\frac{3}{4}$	51.20	54.64	57.80	60.71	63.36	65.76	67.94
8	54.53	58.27	61.73	64.92	67.85	70.52	72.96
8 $\frac{1}{4}$	57.90	61.95	65.71	69.20	72.41	75.37	78.07
8 $\frac{1}{2}$	61.31	65.68	69.75	73.53	77.04	80.28	83.27
8 $\frac{3}{4}$	64.76	69.45	73.83	77.93	81.74	85.27	88.54
9	68.24	73.25	77.96	82.37	86.48	90.32	93.88
9 $\frac{1}{4}$	71.75	77.09	82.12	86.85	91.28	95.43	99.29
9 $\frac{1}{2}$	75.28	80.96	86.32	91.38	96.13	100.59	104.76
9 $\frac{3}{4}$	78.84	84.86	90.56	95.94	101.02	105.79	110.28
10	82.42	88.78	94.82	100.54	105.94	111.04	115.85

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in								
Diameter of Pillar outside.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	$1\frac{1}{8}$ Inch.
Inches.								
2	0.77	0.63	0.71					
$2\frac{1}{4}$	1.17	0.90	1.03	1.11				
$2\frac{1}{2}$	1.71	1.23	1.43	1.56	1.64			
$2\frac{3}{4}$	2.40	1.62	1.91	2.12	2.25	2.33		
3	3.26	2.09	2.49	2.78	2.98	3.12	3.20	
$3\frac{1}{4}$	4.34	2.63	3.16	3.56	3.85	4.06	4.19	4.27
$3\frac{1}{2}$	5.64	3.24	3.93	4.47	4.87	5.16	5.36	5.50
$3\frac{3}{4}$	7.21	3.94	4.81	5.50	6.03	6.43	6.72	6.93
4	9.06	4.73	5.80	6.67	7.35	7.89	8.29	8.58
$4\frac{1}{4}$	11.63	5.16	6.45	7.55	8.48	9.25	9.87	10.37
$4\frac{1}{2}$	13.95	5.86	7.36	8.66	9.77	10.71	11.49	12.12
$4\frac{3}{4}$	16.56	6.60	8.33	9.83	11.14	12.26	13.21	14.00
5	19.46	7.37	9.33	11.06	12.58	13.90	15.03	15.99
$5\frac{1}{4}$	22.65	8.17	10.38	12.35	14.09	15.62	16.95	18.09
$5\frac{1}{2}$	26.16	9.00	11.46	13.68	15.66	17.41	18.95	20.29
$5\frac{3}{4}$	29.99	9.85	12.58	15.06	17.28	19.27	21.03	22.59
6	34.15	10.73	13.74	16.47	18.96	21.19	23.20	24.98
$6\frac{1}{4}$	38.64	11.63	14.92	17.93	20.68	23.18	25.43	27.44
$6\frac{1}{2}$	43.48	12.54	16.13	19.43	22.45	25.21	27.72	29.99
$6\frac{3}{4}$	48.66	13.48	17.36	20.96	24.27	27.30	30.08	32.60
7	54.20	14.43	18.62	22.52	26.12	29.44	32.49	35.28
$7\frac{1}{4}$	60.10	15.40	19.90	24.10	28.00	31.62	34.95	38.02
$7\frac{1}{2}$	66.36	16.39	21.21	25.72	29.92	33.84	37.46	40.82
$7\frac{3}{4}$	72.99	17.38	22.52	27.35	31.87	36.09	40.02	43.66
8	79.99	18.39	23.86	29.01	33.85	38.38	42.61	46.56
$8\frac{1}{4}$	87.37	19.41	25.21	30.69	35.85	40.70	45.24	49.49
$8\frac{1}{2}$	95.12	20.44	26.58	32.39	37.87	43.05	47.91	52.47
$8\frac{3}{4}$	103.26	21.48	27.96	34.10	39.92	45.42	50.60	55.48
9	111.78	22.53	29.35	35.83	41.99	47.82	53.33	58.53
$9\frac{1}{4}$	120.68	23.58	30.75	37.58	44.07	50.24	56.08	61.60
$9\frac{1}{2}$	129.98	24.64	32.16	39.33	46.17	52.67	58.85	64.71
$9\frac{3}{4}$	139.66	25.71	33.58	41.10	48.29	55.13	61.65	67.84
10	149.73	26.79	35.01	42.88	50.41	57.61	64.47	71.00

Cast-iron 10 feet long.

if solid, as in the first column, or if hollow, as in the succeed- the respective headings.							
Diameter of Pillar outside.	1 $\frac{1}{4}$ Inch.	1 $\frac{3}{8}$ Inch.	1 $\frac{1}{2}$ Inch.	1 $\frac{5}{8}$ Inch.	1 $\frac{3}{4}$ Inch.	1 $\frac{7}{8}$ Inch.	2 Inch.
Inches.							
2							
2 $\frac{1}{4}$							
2 $\frac{1}{2}$							
2 $\frac{3}{4}$							
3							
3 $\frac{1}{4}$							
3 $\frac{1}{2}$	5.57						
3 $\frac{3}{4}$	7.06	7.14					
4	8.78	8.92	9.00				
4 $\frac{1}{4}$	10.76	11.06	11.27	11.43			
4 $\frac{1}{2}$	12.64	13.04	13.35	13.57	13.73		
4 $\frac{3}{4}$	14.65	15.18	15.59	15.91	16.15	16.32	
5	16.80	17.46	18.00	18.43	18.76	19.01	19.20
5 $\frac{1}{4}$	19.07	19.89	20.57	21.12	21.57	21.91	22.18
5 $\frac{1}{2}$	21.46	22.45	23.28	23.98	24.55	25.01	25.37
5 $\frac{3}{4}$	23.95	25.13	26.14	26.99	27.71	28.30	28.77
6	26.55	27.93	29.12	30.15	31.03	31.76	32.37
6 $\frac{1}{4}$	29.24	30.83	32.23	33.45	34.49	35.39	36.14
6 $\frac{1}{2}$	32.02	33.84	35.45	36.87	38.10	39.17	40.09
6 $\frac{3}{4}$	34.89	36.94	38.78	40.41	41.85	43.10	44.20
7	37.82	40.12	42.20	44.06	45.71	47.17	48.45
7 $\frac{1}{4}$	40.83	43.39	45.71	47.81	49.69	51.37	52.85
7 $\frac{1}{2}$	43.90	46.73	49.31	51.65	53.77	55.68	57.38
7 $\frac{3}{4}$	47.03	50.14	52.98	55.59	57.95	60.10	62.03
8	50.22	53.60	56.73	59.60	62.23	64.62	66.79
8 $\frac{1}{4}$	53.45	57.13	60.54	63.69	66.58	69.23	71.65
8 $\frac{1}{2}$	56.73	60.71	64.41	67.84	71.01	73.93	76.61
8 $\frac{3}{4}$	60.06	64.34	68.34	72.06	75.52	78.71	81.66
9	63.42	68.02	72.32	76.34	80.09	83.57	86.79
9 $\frac{1}{4}$	66.82	71.73	76.35	80.67	84.72	88.49	91.99
9 $\frac{1}{2}$	70.25	75.49	80.42	85.05	89.40	93.47	97.27
9 $\frac{3}{4}$	73.71	79.28	84.53	89.48	94.14	98.51	102.60
10	77.20	83.10	88.67	93.95	98.92	103.60	108.00

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support,
ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside. Inches.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	$1\frac{1}{8}$ Inch.
2	0.66	0.53	0.60					
$2\frac{1}{4}$	1.00	0.76	0.88	0.94				
$2\frac{1}{2}$	1.45	1.04	1.22	1.33	1.40			
$2\frac{3}{4}$	2.04	1.38	1.63	1.80	1.91	1.98		
3	2.77	1.78	2.12	2.36	2.54	2.65	2.72	
$3\frac{1}{4}$	3.69	2.23	2.69	3.03	3.28	3.45	3.56	3.63
$3\frac{1}{2}$	4.80	2.76	3.34	3.80	4.14	4.39	4.56	4.67
$3\frac{3}{4}$	6.13	3.35	4.09	4.68	5.13	5.47	5.72	5.89
4	7.71	4.02	4.93	5.67	6.25	6.71	7.05	7.30
$4\frac{1}{4}$	9.56	4.76	5.87	6.78	7.52	8.10	8.56	8.90
$4\frac{1}{2}$	12.31	5.24	6.58	7.73	8.70	9.52	10.20	10.76
$4\frac{3}{4}$	14.64	5.92	7.46	8.80	9.96	10.94	11.77	12.46
5	17.24	6.64	8.39	9.93	11.28	12.44	13.44	14.28
$5\frac{1}{4}$	20.13	7.38	9.36	11.12	12.67	14.03	15.20	16.21
$5\frac{1}{2}$	23.30	8.15	10.37	12.35	14.12	15.68	17.05	18.24
$5\frac{3}{4}$	26.77	8.95	11.41	13.64	15.63	17.41	18.98	20.36
6	30.55	9.77	12.49	14.96	17.20	19.20	20.99	22.58
$6\frac{1}{4}$	34.64	10.62	13.61	16.34	18.82	21.06	23.08	24.88
$6\frac{1}{2}$	39.06	11.49	14.75	17.74	20.48	22.97	25.23	27.26
$6\frac{3}{4}$	43.82	12.37	15.92	19.19	22.19	24.94	27.45	29.72
7	48.91	13.28	17.11	20.67	23.95	26.96	29.72	32.24
$7\frac{1}{4}$	54.34	14.20	18.33	22.18	25.74	29.03	32.06	34.83
$7\frac{1}{2}$	60.12	15.14	19.58	23.71	27.57	31.14	34.44	37.49
$7\frac{3}{4}$	66.26	16.10	20.84	25.28	29.43	33.29	36.88	40.19
8	72.76	17.07	22.12	26.87	31.32	35.48	39.35	42.95
$8\frac{1}{4}$	79.62	18.05	23.42	28.49	33.24	37.70	41.88	45.77
$8\frac{1}{2}$	86.84	19.04	24.74	30.12	35.19	39.96	44.43	48.62
$8\frac{3}{4}$	94.44	20.05	26.07	31.78	37.17	42.25	47.03	51.52
9	102.41	21.06	27.42	33.45	39.16	44.56	49.66	54.45
$9\frac{1}{4}$	110.76	22.09	28.78	35.14	41.18	46.90	52.32	57.42
$9\frac{1}{2}$	119.49	23.12	30.15	36.85	43.22	49.27	55.00	60.43
$9\frac{3}{4}$	128.60	24.17	31.54	38.57	45.28	51.66	57.72	63.47
10	138.09	25.21	32.93	40.31	47.35	54.06	60.46	66.53

Cast-iron 11 feet long.

if solid, as in the first column, or if hollow, as in the succeed- the respective headings.							
Diameter of Pillar outside.	1 $\frac{1}{4}$ Inch.	1 $\frac{3}{8}$ Inch.	1 $\frac{1}{2}$ Inch.	1 $\frac{5}{8}$ Inch.	1 $\frac{3}{4}$ Inch.	1 $\frac{7}{8}$ Inch.	2 Inch.
Inches.							
2							
2 $\frac{1}{4}$							
2 $\frac{1}{2}$							
2 $\frac{3}{4}$							
3							
3 $\frac{1}{4}$							
3 $\frac{1}{2}$	4.74						
3 $\frac{3}{4}$	6.00	6.07					
4	7.47	7.58	7.65				
4 $\frac{1}{4}$	9.15	9.32	9.43	9.50			
4 $\frac{1}{2}$	11.20	11.54	11.80	12.00	12.13		
4 $\frac{3}{4}$	13.03	13.48	13.83	14.10	14.30	14.45	
5	14.98	15.56	16.02	16.39	16.67	16.88	17.03
5 $\frac{1}{4}$	17.06	17.78	18.36	18.84	19.22	19.51	19.73
5 $\frac{1}{2}$	19.26	20.13	20.85	21.46	21.95	22.34	22.64
5 $\frac{3}{4}$	21.56	22.60	23.48	24.22	24.84	25.35	25.75
6	23.97	25.19	26.24	27.14	27.90	28.53	29.05
6 $\frac{1}{4}$	26.48	27.89	29.12	30.19	31.11	31.88	32.53
6 $\frac{1}{2}$	29.08	30.70	32.12	33.37	34.46	35.39	36.19
6 $\frac{3}{4}$	31.76	33.60	35.23	36.68	37.95	39.05	40.01
7	34.53	36.59	38.44	40.10	41.56	42.85	43.98
7 $\frac{1}{4}$	37.37	39.67	41.75	43.62	45.30	46.78	48.09
7 $\frac{1}{2}$	40.28	42.83	45.15	47.25	49.15	50.84	52.35
7 $\frac{3}{4}$	43.25	46.06	48.63	50.97	53.10	55.01	56.73
8	46.29	49.37	52.19	54.78	57.15	59.29	61.23
8 $\frac{1}{4}$	49.38	52.73	55.83	58.68	61.29	63.67	65.84
8 $\frac{1}{2}$	52.52	56.16	59.53	62.64	65.52	68.15	70.56
8 $\frac{3}{4}$	55.72	59.64	63.29	66.68	69.82	72.71	75.37
9	58.96	63.17	67.12	70.79	74.20	77.36	80.28
9 $\frac{1}{4}$	62.23	66.75	71.00	74.95	78.65	82.08	85.27
9 $\frac{1}{2}$	65.55	70.38	74.92	79.18	83.16	86.88	90.34
9 $\frac{3}{4}$	68.91	74.05	78.89	83.45	87.73	91.74	95.48
10	72.30	77.75	82.91	87.78	92.36	96.66	100.69

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support,
ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	1 $\frac{1}{8}$ Inch.
Inches.								
2	0.57	0.46	0.52					
2 $\frac{1}{4}$	0.86	0.66	0.75	0.81				
2 $\frac{1}{2}$	1.25	0.90	1.05	1.15	1.20			
2 $\frac{3}{4}$	1.76	1.19	1.40	1.55	1.65	1.71		
3	2.39	1.53	1.83	2.04	2.19	2.29	2.34	
3 $\frac{1}{4}$	3.18	1.93	2.32	2.61	2.83	2.98	3.07	3.13
3 $\frac{1}{2}$	4.14	2.38	2.88	3.27	3.57	3.78	3.93	4.03
3 $\frac{3}{4}$	5.29	2.89	3.53	4.03	4.42	4.72	4.93	5.08
4	6.65	3.47	4.25	4.89	5.39	5.78	6.08	6.29
4 $\frac{1}{4}$	8.24	4.10	5.06	5.85	6.48	6.99	7.38	7.67
4 $\frac{1}{2}$	10.10	4.81	5.96	6.92	7.70	8.34	8.84	9.23
4 $\frac{3}{4}$	12.23	5.59	6.95	8.10	9.05	9.84	10.48	10.98
5	15.38	6.00	7.57	8.96	10.16	11.19	12.08	12.82
5 $\frac{1}{4}$	17.99	6.69	8.47	10.05	11.44	12.65	13.70	14.59
5 $\frac{1}{2}$	20.86	7.40	9.41	11.20	12.78	14.18	15.40	16.46
5 $\frac{3}{4}$	24.02	8.15	10.38	12.39	14.19	15.79	17.19	18.42
6	27.46	8.92	11.39	13.63	15.65	17.46	19.06	20.48
6 $\frac{1}{4}$	31.21	9.72	12.44	14.92	17.17	19.19	21.01	22.63
6 $\frac{1}{2}$	35.25	10.54	13.51	16.24	18.73	20.99	23.02	24.85
6 $\frac{3}{4}$	39.61	11.37	14.62	17.61	20.34	22.84	25.11	27.16
7	44.30	12.24	15.75	19.00	22.00	24.74	27.25	29.53
7 $\frac{1}{4}$	49.30	13.11	16.91	20.44	23.70	26.70	29.46	31.98
7 $\frac{1}{2}$	54.65	14.01	18.10	21.90	25.43	28.70	31.72	34.49
7 $\frac{3}{4}$	60.33	14.92	19.30	23.39	27.21	30.75	34.03	37.06
8	66.36	15.85	20.53	24.91	29.01	32.84	36.39	39.69
8 $\frac{1}{4}$	72.74	16.80	21.78	26.46	30.85	34.96	38.80	42.37
8 $\frac{1}{2}$	79.47	17.75	23.04	28.03	32.72	37.13	41.25	45.09
8 $\frac{3}{4}$	86.56	18.72	24.33	29.62	34.62	39.32	43.74	47.87
9	94.02	19.70	25.63	31.24	36.54	41.55	46.26	50.69
9 $\frac{1}{4}$	101.84	20.70	26.94	32.87	38.49	43.81	48.83	53.55
9 $\frac{1}{2}$	110.03	21.70	28.27	34.53	40.46	46.09	51.42	56.45
9 $\frac{3}{4}$	118.59	22.71	29.61	36.19	42.46	48.40	54.05	59.38
10	127.53	23.73	30.97	37.88	44.47	50.74	56.70	62.35

Cast-iron 12 feet long.

if solid, as in the first column, or if hollow, as in the succeed- the respective headings.							
Diameter of Pillar outside.	1 $\frac{1}{4}$ Inch.	1 $\frac{3}{8}$ Inch.	1 $\frac{1}{2}$ Inch.	1 $\frac{5}{8}$ Inch.	1 $\frac{3}{4}$ Inch.	1 $\frac{7}{8}$ Inch.	2 Inch.
Inches.							
2							
2 $\frac{1}{4}$							
2 $\frac{1}{2}$							
2 $\frac{3}{4}$							
3							
3 $\frac{1}{4}$							
3 $\frac{1}{2}$	4.09						
3 $\frac{3}{4}$	5.18	5.24					
4	6.44	6.54	6.60				
4 $\frac{1}{4}$	7.89	8.04	8.14	8.19			
4 $\frac{1}{2}$	9.53	9.74	9.89	9.99	10.05		
4 $\frac{3}{4}$	11.37	11.66	11.88	12.03	12.13	12.18	
5	13.44	13.94	14.34	14.66	14.90	15.08	15.21
5 $\frac{1}{4}$	15.34	15.97	16.48	16.90	17.22	17.47	17.66
5 $\frac{1}{2}$	17.36	18.13	18.77	19.29	19.72	20.05	20.32
5 $\frac{3}{4}$	19.49	20.41	21.19	21.84	22.38	22.81	23.16
6	21.73	22.81	23.73	24.53	25.19	25.74	26.20
6 $\frac{1}{4}$	24.06	25.31	26.41	27.35	28.16	28.84	29.41
6 $\frac{1}{2}$	26.48	27.93	29.20	30.31	31.27	32.09	32.79
6 $\frac{3}{4}$	29.00	30.64	32.11	33.39	34.52	35.50	36.33
7	31.60	33.45	35.11	36.59	37.90	39.04	40.04
7 $\frac{1}{4}$	34.27	36.35	38.22	39.90	41.40	42.72	43.88
7 $\frac{1}{2}$	37.02	39.33	41.43	43.32	45.02	46.53	47.88
7 $\frac{3}{4}$	39.84	42.39	44.72	46.83	48.74	50.46	52.00
8	42.73	45.53	48.10	50.44	52.57	54.50	56.24
8 $\frac{1}{4}$	45.67	48.73	51.55	54.14	56.50	58.65	60.61
8 $\frac{1}{2}$	48.68	52.00	55.08	57.91	60.52	62.91	65.08
8 $\frac{3}{4}$	51.73	55.33	58.67	61.77	64.62	67.25	69.66
9	54.84	58.72	62.33	65.69	68.81	71.69	74.34
9 $\frac{1}{4}$	57.99	62.16	66.05	69.69	73.07	76.21	79.11
9 $\frac{1}{2}$	61.19	65.65	69.83	73.74	77.40	80.80	83.96
9 $\frac{3}{4}$	64.43	69.19	73.66	77.86	81.80	85.47	88.90
10	67.71	72.77	77.54	82.03	86.26	90.21	93.91

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support,
ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside. Inches.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	$1\frac{1}{8}$ Inch.
2	0.49	0.40	0.45					
$2\frac{1}{4}$	0.75	0.57	0.66	0.71				
$2\frac{1}{2}$	1.09	0.79	0.92	1.00	1.05			
$2\frac{3}{4}$	1.53	1.04	1.23	1.36	1.44	1.49		
3	2.09	1.34	1.59	1.78	1.91	2.00	2.05	
$3\frac{1}{4}$	2.78	1.68	2.02	2.28	2.47	2.60	2.68	2.73
$3\frac{1}{2}$	3.61	2.08	2.52	2.86	3.12	3.30	3.43	3.52
$3\frac{3}{4}$	4.61	2.52	3.08	3.52	3.86	4.12	4.30	4.43
4	5.80	3.02	3.71	4.27	4.71	5.05	5.31	5.49
$4\frac{1}{4}$	7.19	3.58	4.42	5.10	5.66	6.10	6.44	6.70
$4\frac{1}{2}$	8.81	4.20	5.20	6.04	6.72	7.28	7.72	8.06
$4\frac{3}{4}$	10.68	4.88	6.06	7.07	7.90	8.59	9.14	9.58
5	12.81	5.62	7.01	8.20	9.20	10.03	10.72	11.28
$5\frac{1}{4}$	16.17	6.08	7.70	9.12	10.37	11.46	12.40	13.19
$5\frac{1}{2}$	18.78	6.75	8.57	10.19	11.62	12.88	13.97	14.92
$5\frac{3}{4}$	21.66	7.45	9.48	11.30	12.93	14.37	15.63	16.74
6	24.81	8.17	10.42	12.46	14.29	15.92	17.37	18.65
$6\frac{1}{4}$	28.23	8.91	11.40	13.66	15.70	17.54	19.18	20.64
$6\frac{1}{2}$	31.95	9.69	12.41	14.91	17.17	19.22	21.07	22.72
$6\frac{3}{4}$	35.96	10.48	13.46	16.19	18.69	20.96	23.02	24.88
7	40.27	11.29	14.53	17.51	20.25	22.76	25.04	27.12
$7\frac{1}{4}$	44.90	12.13	15.63	18.87	21.86	24.60	27.12	29.42
$7\frac{1}{2}$	49.84	12.98	16.75	20.26	23.50	26.50	29.26	31.79
$7\frac{3}{4}$	55.11	13.85	17.90	21.68	25.19	28.45	31.45	34.23
8	60.70	14.74	19.07	23.13	26.91	30.43	33.70	36.72
$8\frac{1}{4}$	66.64	15.64	20.27	24.61	28.67	32.46	35.99	39.27
$8\frac{1}{2}$	72.91	16.56	21.48	26.11	30.46	34.53	38.33	41.87
$8\frac{3}{4}$	79.53	17.49	22.71	27.64	32.28	36.63	40.71	44.53
9	86.50	18.44	23.97	29.19	34.13	38.77	43.14	47.23
$9\frac{1}{4}$	93.82	19.40	25.23	30.77	36.00	40.94	45.60	49.98
$9\frac{1}{2}$	101.51	20.37	26.52	32.36	37.90	43.14	48.10	52.77
$9\frac{3}{4}$	109.55	21.35	27.82	33.98	39.83	45.38	50.63	55.60
10	117.96	22.34	29.13	35.61	41.77	47.63	53.20	58.46

Cast-iron 13 feet long.

if solid, as in the first column, or if hollow, as in the succeed- the respective headings.							
Diameter of Pillar outside.	1 $\frac{1}{4}$ Inch.	1 $\frac{3}{8}$ Inch.	1 $\frac{1}{2}$ Inch.	1 $\frac{5}{8}$ Inch.	1 $\frac{3}{4}$ Inch.	1 $\frac{7}{8}$ Inch.	2 Inch.
Inches.							
2							
2 $\frac{1}{4}$							
2 $\frac{1}{2}$							
2 $\frac{3}{4}$							
3							
3 $\frac{1}{4}$							
3 $\frac{1}{2}$	3.57						
3 $\frac{3}{4}$	4.52	4.57					
4	5.62	5.71	5.76				
4 $\frac{1}{4}$	6.89	7.02	7.10	7.15			
4 $\frac{1}{2}$	8.32	8.50	8.63	8.72	8.77		
4 $\frac{3}{4}$	9.92	10.18	10.37	10.50	10.58	10.63	
5	11.72	12.06	12.31	12.50	12.63	12.72	12.77
5 $\frac{1}{4}$	13.86	14.41	14.87	15.23	15.52	15.73	15.89
5 $\frac{1}{2}$	15.72	16.40	16.97	17.43	17.80	18.09	18.32
5 $\frac{3}{4}$	17.69	18.51	19.20	19.77	20.25	20.63	20.93
6	19.76	20.73	21.55	22.26	22.84	23.33	23.72
6 $\frac{1}{4}$	21.93	23.06	24.03	24.87	25.59	26.19	26.69
6 $\frac{1}{2}$	24.20	25.49	26.63	27.62	28.48	29.21	29.82
6 $\frac{3}{4}$	26.55	28.03	29.34	30.50	31.50	32.37	33.11
7	28.99	30.66	32.16	33.49	34.66	35.68	36.56
7 $\frac{1}{4}$	31.50	33.39	35.08	36.59	37.94	39.12	40.16
7 $\frac{1}{2}$	34.10	36.20	38.10	39.81	41.34	42.70	43.90
7 $\frac{3}{4}$	36.77	39.09	41.21	43.12	44.85	46.39	47.77
8	39.50	42.06	44.40	46.53	48.46	50.21	51.77
8 $\frac{1}{4}$	42.30	45.10	47.68	50.03	52.18	54.13	55.89
8 $\frac{1}{2}$	45.17	48.22	51.03	53.62	56.00	58.16	60.13
8 $\frac{3}{4}$	48.09	51.39	54.46	57.29	59.90	62.29	64.48
9	51.06	54.63	57.96	61.04	63.89	66.52	68.93
9 $\frac{1}{4}$	54.08	57.93	61.52	64.86	67.96	70.83	73.48
9 $\frac{1}{2}$	57.16	61.28	65.14	68.75	72.11	75.23	78.12
9 $\frac{3}{4}$	60.28	64.68	68.82	72.70	76.33	79.70	82.85
10	63.44	68.14	72.56	76.71	80.61	84.26	87.66

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support,
ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	$1\frac{1}{8}$ Inch.
Inches.								
2	0.44	0.35	0.40					
$2\frac{1}{4}$	0.66	0.51	0.58	0.63				
$2\frac{1}{2}$	0.96	0.69	0.81	0.88	0.93			
$2\frac{3}{4}$	1.35	0.91	1.08	1.19	1.27	1.31		
3	1.84	1.18	1.40	1.57	1.68	1.76	1.80	
$3\frac{1}{4}$	2.45	1.48	1.78	2.01	2.17	2.29	2.36	2.41
$3\frac{1}{2}$	3.18	1.83	2.20	2.52	2.75	2.91	3.03	3.10
$3\frac{3}{4}$	4.07	2.22	2.71	3.10	3.40	3.63	3.79	3.91
4	5.11	2.67	3.27	3.76	4.15	4.45	4.68	4.84
$4\frac{1}{4}$	6.34	3.16	3.90	4.50	4.99	5.38	5.68	5.81
$4\frac{1}{2}$	7.77	3.70	4.58	5.32	5.93	6.42	6.80	7.11
$4\frac{3}{4}$	9.41	4.30	5.35	6.23	6.97	7.57	8.06	8.45
5	11.29	4.95	6.18	7.23	8.11	8.85	9.45	9.94
$5\frac{1}{4}$	13.43	5.66	7.09	8.31	9.36	10.24	10.98	11.59
$5\frac{1}{2}$	15.84	6.43	8.07	9.50	10.73	11.77	12.66	13.39
$5\frac{3}{4}$	19.63	6.82	8.68	10.34	11.82	13.12	14.27	15.26
6	22.51	7.50	9.56	11.42	13.09	14.57	15.88	17.04
$6\frac{1}{4}$	25.65	8.20	10.48	12.55	14.41	16.08	17.58	18.90
$6\frac{1}{2}$	29.07	8.93	11.43	13.71	15.79	17.66	19.34	20.84
$6\frac{3}{4}$	32.77	9.68	12.41	14.92	17.21	19.29	21.17	22.86
7	36.75	10.45	13.43	16.17	18.68	20.98	23.07	24.96
$7\frac{1}{4}$	41.02	11.24	14.47	17.45	20.20	22.72	25.03	27.13
$7\frac{1}{2}$	45.60	12.05	15.53	18.77	21.76	24.52	27.05	29.37
$7\frac{3}{4}$	50.49	12.88	16.63	20.12	23.36	26.36	29.13	31.67
8	55.69	13.72	17.75	21.50	25.00	28.25	31.26	34.04
$8\frac{1}{4}$	61.22	14.59	18.88	22.91	26.67	30.18	33.44	36.46
$8\frac{1}{2}$	67.07	15.47	20.05	24.35	28.38	32.15	35.67	38.94
$8\frac{3}{4}$	73.25	16.36	21.23	25.81	30.12	34.17	37.95	41.48
9	79.77	17.27	22.43	27.30	31.90	36.22	40.27	44.06
$9\frac{1}{4}$	86.63	18.19	23.65	28.82	33.70	38.30	42.63	46.69
$9\frac{1}{2}$	93.84	19.13	24.89	30.35	35.53	40.42	45.03	49.37
$9\frac{3}{4}$	101.40	20.07	26.14	31.91	37.38	42.57	47.46	52.09
10	109.31	21.03	27.41	33.49	39.26	44.74	49.94	54.85

Cast-iron 14 feet long.

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1 $\frac{1}{4}$ Inch.	1 $\frac{3}{8}$ Inch.	1 $\frac{1}{2}$ Inch.	1 $\frac{5}{8}$ Inch.	1 $\frac{3}{4}$ Inch.	1 $\frac{7}{8}$ Inch.	2 Inch.
Inches.							
2							
2 $\frac{1}{4}$							
2 $\frac{1}{2}$							
2 $\frac{3}{4}$							
3							
3 $\frac{1}{4}$							
3 $\frac{1}{2}$	3.15						
3 $\frac{3}{4}$	3.98	4.03					
4	4.96	5.03	5.08				
4 $\frac{1}{4}$	6.07	6.19	6.26	6.31			
4 $\frac{1}{2}$	7.33	7.50	7.61	7.69	7.73		
4 $\frac{3}{4}$	8.75	8.98	9.14	9.26	9.33	9.39	
5	10.33	10.63	10.86	11.02	11.14	11.21	11.26
5 $\frac{1}{4}$	12.08	12.46	12.77	12.99	13.16	13.27	13.35
5 $\frac{1}{2}$	14.00	14.49	14.88	15.18	15.40	15.57	15.68
5 $\frac{3}{4}$	16.12	16.85	17.46	17.98	18.40	18.73	19.00
6	18.04	18.91	19.65	20.28	20.80	21.23	21.57
6 $\frac{1}{4}$	20.06	21.07	21.95	22.70	23.34	23.87	24.31
6 $\frac{1}{2}$	22.17	23.35	24.37	25.26	26.02	26.67	27.22
6 $\frac{3}{4}$	24.37	25.72	26.90	27.94	28.84	29.62	30.28
7	26.66	28.19	29.54	30.74	31.79	32.70	33.50
7 $\frac{1}{4}$	29.03	30.74	32.28	33.67	34.86	35.93	36.86
7 $\frac{1}{2}$	31.48	33.39	35.12	36.67	38.05	39.28	40.36
7 $\frac{3}{4}$	34.00	36.12	38.05	39.79	41.36	42.76	44.00
8	36.59	38.93	41.07	43.01	44.77	46.35	47.76
8 $\frac{1}{4}$	39.25	41.82	44.18	46.33	48.29	50.06	51.66
8 $\frac{1}{2}$	41.98	44.78	47.36	49.73	51.90	53.87	55.66
8 $\frac{3}{4}$	44.76	47.81	50.62	53.22	55.61	57.79	59.79
9	47.60	50.90	53.96	56.79	59.41	61.81	64.02
9 $\frac{1}{4}$	50.50	54.05	57.36	60.44	63.29	65.92	68.35
9 $\frac{1}{2}$	53.44	57.26	60.83	64.16	67.25	70.12	72.77
9 $\frac{3}{4}$	56.44	60.53	64.36	67.95	71.29	74.40	77.29
10	59.48	63.85	67.95	71.80	75.40	78.77	81.90

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support,
ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	$1\frac{1}{8}$ Inch.
Inches.								
2	0.39	0.32	0.36					
$2\frac{1}{4}$	0.59	0.45	0.52	0.56				
$2\frac{1}{2}$	0.86	0.62	0.72	0.78	0.82			
$2\frac{3}{4}$	1.20	0.81	0.96	1.06	1.13	1.17		
3	1.64	1.05	1.25	1.40	1.50	1.56	1.60	
$3\frac{1}{4}$	2.18	1.32	1.59	1.79	1.93	2.04	2.10	2.14
$3\frac{1}{2}$	2.83	1.63	1.97	2.24	2.44	2.59	2.69	2.76
$3\frac{3}{4}$	3.62	1.98	2.41	2.76	3.03	3.23	3.38	3.48
4	4.55	2.37	2.91	3.35	3.69	3.96	4.16	4.31
$4\frac{1}{4}$	5.64	2.81	3.46	4.00	4.44	4.78	5.05	5.25
$4\frac{1}{2}$	6.91	3.29	4.08	4.73	5.27	5.71	6.05	6.32
$4\frac{3}{4}$	8.37	3.82	4.75	5.54	6.20	6.73	7.17	7.51
5	10.04	4.40	5.50	6.43	7.21	7.87	8.41	8.84
$5\frac{1}{4}$	11.94	5.03	6.30	7.39	8.33	9.11	9.77	10.30
$5\frac{1}{2}$	14.09	5.72	7.18	8.45	9.54	10.47	11.26	11.91
$5\frac{3}{4}$	16.50	6.45	8.12	9.59	10.86	11.95	12.88	13.66
6	19.19	7.24	9.14	10.81	12.28	13.55	14.64	15.57
$6\frac{1}{4}$	23.41	7.57	9.66	11.55	13.26	14.79	16.15	17.35
$6\frac{1}{2}$	26.56	8.25	10.55	12.65	14.55	16.27	17.80	19.17
$6\frac{3}{4}$	29.97	8.95	11.48	13.79	15.89	17.80	19.52	21.07
7	33.65	9.68	12.43	14.96	17.28	19.39	21.31	23.04
$7\frac{1}{4}$	37.62	10.43	13.42	16.18	18.71	21.03	23.15	25.08
$7\frac{1}{2}$	41.86	11.20	14.43	17.42	20.19	22.73	25.06	27.19
$7\frac{3}{4}$	46.41	11.99	15.47	18.71	21.71	24.48	27.03	29.37
8	51.25	12.80	16.53	20.02	23.26	26.27	29.05	31.61
$8\frac{1}{4}$	56.40	13.62	17.62	21.36	24.86	28.11	31.12	33.91
$8\frac{1}{2}$	61.86	14.46	18.73	22.74	26.49	29.99	33.25	36.27
$8\frac{3}{4}$	67.63	15.32	19.86	24.14	28.15	31.91	35.42	38.69
9	73.74	16.19	21.02	25.57	29.85	33.87	37.63	41.15
$9\frac{1}{4}$	80.17	17.08	22.19	27.02	31.58	35.87	39.89	43.67
$9\frac{1}{2}$	86.93	17.98	23.38	28.50	33.33	37.90	42.20	46.24
$9\frac{3}{4}$	94.04	18.89	24.59	30.00	35.12	39.96	44.54	48.85
10	101.48	19.82	25.81	31.52	36.93	42.06	46.91	51.50

Cast-iron 15 feet long.

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1 $\frac{1}{4}$ Inch.	1 $\frac{3}{8}$ Inch.	1 $\frac{1}{2}$ Inch.	1 $\frac{5}{8}$ Inch.	1 $\frac{3}{4}$ Inch.	1 $\frac{7}{8}$ Inch.	2 Inch.
Inches.							
2							
2 $\frac{1}{4}$							
2 $\frac{1}{2}$							
2 $\frac{3}{4}$							
3							
3 $\frac{1}{4}$							
3 $\frac{1}{2}$	2.80						
3 $\frac{3}{4}$	3.54	3.58					
4	4.41	4.48	4.52				
4 $\frac{1}{4}$	5.40	5.50	5.57	5.61			
4 $\frac{1}{2}$	6.52	6.67	6.77	6.84	6.88		
4 $\frac{3}{4}$	7.78	7.98	8.13	8.23	8.30	8.34	
5	9.19	9.45	9.66	9.80	9.90	9.97	10.01
5 $\frac{1}{4}$	10.74	11.09	11.35	11.55	11.70	11.80	11.87
5 $\frac{1}{2}$	12.45	12.88	13.23	13.50	13.70	13.85	13.95
5 $\frac{3}{4}$	14.32	14.86	15.29	15.64	15.91	16.11	16.25
6	16.35	17.01	17.55	17.98	18.33	18.60	18.80
6 $\frac{1}{4}$	18.41	19.33	20.12	20.80	21.37	21.84	22.24
6 $\frac{1}{2}$	20.38	21.45	22.37	23.18	23.86	24.45	24.93
6 $\frac{3}{4}$	22.44	23.66	24.74	25.68	26.49	27.19	27.78
7	24.59	25.98	27.21	28.30	29.25	30.07	30.78
7 $\frac{1}{4}$	26.82	28.38	29.78	31.03	32.12	33.09	33.92
7 $\frac{1}{2}$	29.12	30.87	32.45	33.86	35.12	36.23	37.21
7 $\frac{3}{4}$	31.51	33.45	35.21	36.80	38.23	39.50	40.62
8	33.96	36.11	38.07	39.84	41.45	42.89	44.17
8 $\frac{1}{4}$	36.48	38.85	41.01	42.98	44.77	46.39	47.84
8 $\frac{1}{2}$	39.07	41.66	44.03	46.21	48.19	50.00	51.63
8 $\frac{3}{4}$	41.72	44.54	47.13	49.52	51.71	53.72	55.54
9	44.43	47.48	50.31	52.92	55.33	57.53	59.55
9 $\frac{1}{4}$	47.20	50.49	53.56	56.40	59.02	61.45	63.67
9 $\frac{1}{2}$	50.02	53.57	56.87	59.95	62.81	65.45	67.89
9 $\frac{3}{4}$	52.90	56.70	60.25	63.58	66.67	69.54	72.20
10	55.82	59.88	63.70	67.27	70.61	73.72	76.61

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support,
ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	$1\frac{1}{8}$ Inch.
Inches.								
2	0.35	0.28	0.32					
$2\frac{1}{4}$	0.53	0.40	0.46	0.50				
$2\frac{1}{2}$	0.77	0.55	0.64	0.70	0.74			
$2\frac{3}{4}$	1.08	0.73	0.86	0.95	1.01	1.05		
3	1.47	0.94	1.12	1.25	1.34	1.40	1.44	
$3\frac{1}{4}$	1.95	1.18	1.42	1.60	1.73	1.82	1.88	1.92
$3\frac{1}{2}$	2.54	1.46	1.77	2.01	2.19	2.32	2.41	2.47
$3\frac{3}{4}$	3.24	1.77	2.16	2.47	2.71	2.89	3.02	3.12
4	4.08	2.13	2.61	3.00	3.31	3.55	3.73	3.86
$4\frac{1}{4}$	5.05	2.52	3.10	3.59	3.98	4.29	4.53	4.71
$4\frac{1}{2}$	6.19	2.95	3.65	5.24	4.72	5.11	5.42	5.66
$4\frac{3}{4}$	7.50	3.43	4.26	4.96	5.55	6.03	6.42	6.73
5	9.00	3.95	4.92	5.76	6.46	7.05	7.53	7.92
$5\frac{1}{4}$	10.70	4.51	5.65	6.63	7.46	8.16	8.75	9.23
$5\frac{1}{2}$	12.62	5.12	6.43	7.57	8.55	9.38	10.09	10.67
$5\frac{3}{4}$	14.78	5.78	7.28	8.59	9.73	10.71	11.54	12.24
6	17.19	6.49	8.19	9.69	11.00	12.14	13.12	13.95
$6\frac{1}{4}$	19.87	7.25	9.17	10.87	12.37	13.68	14.82	15.80
$6\frac{1}{2}$	24.35	7.64	9.77	11.70	13.45	15.02	16.43	17.68
$6\frac{3}{4}$	27.51	8.30	10.64	12.77	14.71	16.47	18.05	19.46
7	30.92	8.99	11.54	13.88	16.02	17.96	19.72	21.31
$7\frac{1}{4}$	34.60	9.70	12.47	15.03	17.37	19.51	21.47	23.24
$7\frac{1}{2}$	38.55	10.43	13.43	16.21	18.77	21.12	23.27	25.23
$7\frac{3}{4}$	42.78	11.18	14.42	17.42	20.21	22.77	25.13	27.29
8	47.29	11.95	15.43	18.67	21.68	24.47	27.04	29.41
$8\frac{1}{4}$	52.10	12.74	16.47	19.95	23.20	26.22	29.01	31.60
$8\frac{1}{2}$	57.20	13.54	17.53	21.26	24.75	28.01	31.03	33.84
$8\frac{3}{4}$	62.61	14.36	18.61	22.60	26.34	29.84	33.10	36.14
9	68.32	15.20	19.71	23.97	27.97	31.71	35.22	38.49
$9\frac{1}{4}$	74.36	16.05	20.84	25.36	29.62	33.63	37.38	40.90
$9\frac{1}{2}$	80.71	16.91	21.98	26.78	31.31	35.57	39.59	43.35
$9\frac{3}{4}$	87.39	17.79	23.14	28.22	33.02	37.56	41.83	45.86
10	94.40	18.68	24.33	29.68	34.76	39.57	44.12	48.40

Cast-iron 16 feet long.

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1½ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.	2¼ Inch.	2½ Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	2.51						
3¾	3.18	3.21					
4	3.95	4.01	4.05				
4¼	4.84	4.93	4.99	5.02			
4½	5.84	5.97	6.07	6.13	6.16		
4¾	6.97	7.15	7.29	7.38	7.44	7.47	
5	8.23	8.47	8.65	8.78	8.87	8.93	8.97
5¼	9.62	9.93	10.17	10.35	10.49	10.58	10.64
5½	11.16	11.55	11.86	12.10	12.28	12.41	12.50
5¾	12.83	13.31	13.70	14.01	14.25	14.43	14.57
6	14.66	15.24	15.72	16.11	16.42	16.66	16.84
6¼	16.63	17.34	17.92	18.41	18.80	19.11	19.34
6½	18.79	19.76	20.61	21.33	21.95	22.48	22.91
6¾	20.72	21.84	22.82	23.67	24.41	25.04	25.57
7	22.74	24.01	25.13	26.12	26.98	27.73	28.37
7¼	24.83	26.27	27.55	28.68	29.68	30.55	31.31
7½	27.01	28.61	30.06	31.35	32.49	33.51	34.39
7¾	29.26	31.05	32.66	34.12	35.42	36.58	37.60
8	31.58	33.56	35.36	36.99	38.46	39.77	40.94
8¼	33.97	36.15	38.14	39.96	41.60	43.08	44.41
8½	36.43	38.82	41.01	43.01	44.84	46.50	47.99
8¾	38.95	41.56	43.96	46.16	48.18	50.02	51.69
9	41.54	44.36	46.98	49.39	51.61	53.64	55.50
9¼	44.18	47.24	50.08	52.71	55.13	57.37	59.41
9½	46.88	50.17	53.24	56.10	58.74	61.18	63.43
9¾	49.63	53.17	56.48	59.56	62.43	65.09	67.54
10	52.44	56.23	59.78	63.10	66.20	69.08	71.75

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in								
Diameter of Pillar outside. Inches.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	$1\frac{1}{8}$ Inch.
2	0.31	0.25	0.29					
$2\frac{1}{4}$	0.48	0.36	0.42	0.45				
$2\frac{1}{2}$	0.69	0.50	0.58	0.63	0.67			
$2\frac{3}{4}$	0.97	0.66	0.78	0.86	0.91	0.94		
3	1.32	0.85	1.01	1.13	1.21	1.26	1.30	
$3\frac{1}{4}$	1.76	1.07	1.28	1.44	1.56	1.65	1.70	1.73
$3\frac{1}{2}$	2.29	1.32	1.60	1.81	1.97	2.09	2.18	2.23
$3\frac{3}{4}$	2.92	1.60	1.95	2.23	2.45	2.61	2.73	2.81
4	3.68	1.92	2.35	2.70	2.98	3.20	3.36	3.48
$4\frac{1}{4}$	4.56	2.27	2.80	3.24	3.59	3.87	4.08	4.25
$4\frac{1}{2}$	5.58	2.66	3.30	3.83	4.26	4.61	4.89	5.11
$4\frac{3}{4}$	6.77	3.09	3.84	4.48	5.01	5.44	5.79	6.07
5	8.12	3.56	4.44	5.19	5.83	6.36	6.79	7.15
$5\frac{1}{4}$	9.65	4.07	5.09	5.98	6.73	7.36	7.89	8.33
$5\frac{1}{2}$	11.39	4.62	5.80	6.83	7.71	8.46	9.10	9.63
$5\frac{3}{4}$	13.33	5.21	6.57	7.75	8.77	9.66	10.41	11.04
6	15.51	5.85	7.39	8.74	9.92	10.95	11.83	12.58
$6\frac{1}{4}$	17.93	6.54	8.27	9.81	11.16	12.34	13.37	14.25
$6\frac{1}{2}$	20.61	7.27	9.22	10.95	12.49	13.84	15.02	16.05
$6\frac{3}{4}$	23.56	8.05	10.23	12.17	13.91	15.44	16.79	17.97
7	28.51	8.87	10.74	12.90	14.88	16.68	18.31	19.77
$7\frac{1}{4}$	31.93	9.04	11.62	13.99	16.16	18.14	19.95	21.58
$7\frac{1}{2}$	35.61	9.73	12.53	15.11	17.48	19.66	21.65	23.46
$7\frac{3}{4}$	39.55	10.45	13.46	16.26	18.84	21.22	23.41	25.41
8	43.76	11.18	14.42	17.45	20.25	22.84	25.23	27.42
$8\frac{1}{4}$	48.25	11.93	15.41	18.66	21.69	24.50	27.10	29.49
$8\frac{1}{2}$	53.03	12.69	16.42	19.91	23.17	26.20	29.02	31.62
$8\frac{3}{4}$	58.09	13.48	17.46	21.19	24.69	27.95	30.99	33.81
9	63.45	14.28	18.51	22.50	26.24	29.74	33.01	36.06
$9\frac{1}{4}$	69.12	15.10	19.59	23.83	27.82	31.57	35.07	38.35
$9\frac{1}{2}$	75.09	15.93	20.69	25.19	29.44	33.43	37.19	40.70
$9\frac{3}{4}$	81.38	16.77	21.81	26.58	31.08	35.33	39.34	43.10
10	87.98	17.63	22.94	27.98	32.76	37.27	41.53	45.55

Cast-iron 17 feet long.

if solid, as in the first column, or if hollow, as in the succeeding the respective headings.							
Diameter of Pillar outside.	1 $\frac{1}{4}$ Inch.	1 $\frac{3}{8}$ Inch.	1 $\frac{1}{2}$ Inch.	1 $\frac{5}{8}$ Inch.	1 $\frac{3}{4}$ Inch.	1 $\frac{7}{8}$ Inch.	2 Inch.
Inches.							
2							
2 $\frac{1}{4}$							
2 $\frac{1}{2}$							
2 $\frac{3}{4}$							
3							
3 $\frac{1}{4}$							
3 $\frac{1}{2}$	2.26						
3 $\frac{3}{4}$	2.86	2.90					
4	3.56	3.62	3.65				
4 $\frac{1}{4}$	4.36	4.45	4.50	4.53			
4 $\frac{1}{2}$	5.27	5.39	5.47	5.53	5.56		
4 $\frac{3}{4}$	6.29	6.45	6.57	6.65	6.71	6.74	
5	7.43	7.64	7.80	7.92	8.01	8.06	8.09
5 $\frac{1}{4}$	8.68	8.96	9.18	9.34	9.46	9.54	9.59
5 $\frac{1}{2}$	10.06	10.42	10.69	10.91	11.07	11.19	11.27
5 $\frac{3}{4}$	11.57	12.01	12.36	12.64	12.86	13.02	13.14
6	13.22	13.75	14.18	14.54	14.82	15.03	15.19
6 $\frac{1}{4}$	15.00	15.64	16.17	16.60	16.95	17.23	17.45
6 $\frac{1}{2}$	16.93	17.68	18.32	18.85	19.28	19.63	19.91
6 $\frac{3}{4}$	19.00	19.88	20.64	21.27	21.80	22.24	22.59
7	21.08	22.24	23.27	24.18	24.97	25.65	26.23
7 $\frac{1}{4}$	23.05	24.37	25.54	26.58	27.50	28.29	28.98
7 $\frac{1}{2}$	25.10	26.58	27.91	29.09	30.14	31.06	31.87
7 $\frac{3}{4}$	27.23	28.88	30.37	31.70	32.90	33.96	34.89
8	29.42	31.25	32.91	34.41	35.76	36.97	38.04
8 $\frac{1}{4}$	31.69	33.71	35.55	37.22	38.73	40.09	41.31
8 $\frac{1}{2}$	34.03	36.24	38.27	40.12	41.80	43.33	44.70
8 $\frac{3}{4}$	36.43	38.84	41.07	43.11	44.97	46.66	48.20
9	38.89	41.52	43.94	46.18	48.23	50.10	51.81
9 $\frac{1}{4}$	41.41	44.26	46.89	49.33	51.58	53.64	55.53
9 $\frac{1}{2}$	43.99	47.06	49.92	52.57	55.02	57.28	59.36
9 $\frac{3}{4}$	46.63	49.93	53.01	55.88	58.54	61.00	63.28
10	49.32	52.85	56.17	59.26	62.14	64.82	67.30

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in								
Diameter of Pillar outside.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	$1\frac{1}{8}$ Inch.
Inches.								
2	0.28	0.23	0.26					
$2\frac{1}{4}$	0.43	0.33	0.38	0.41				
$2\frac{1}{2}$	0.63	0.45	0.53	0.58	0.60			
$2\frac{3}{4}$	0.88	0.60	0.70	0.78	0.83	0.86		
3	1.20	0.77	0.92	1.02	1.10	1.15	1.18	
$3\frac{1}{4}$	1.60	0.97	1.16	1.31	1.42	1.49	1.54	1.57
$3\frac{1}{2}$	2.08	1.19	1.45	1.64	1.79	1.90	1.97	2.02
$3\frac{3}{4}$	2.65	1.45	1.77	2.02	2.22	2.37	2.48	2.55
4	3.34	1.74	2.13	2.45	2.71	2.90	3.05	3.16
$4\frac{1}{4}$	4.14	2.06	2.54	2.94	3.26	3.51	3.70	3.85
$4\frac{1}{2}$	5.07	2.41	2.99	3.47	3.87	4.19	4.44	4.64
$4\frac{3}{4}$	6.14	2.80	3.49	4.06	4.54	4.94	5.26	5.51
5	7.37	3.23	4.03	4.71	5.29	5.77	6.17	6.48
$5\frac{1}{4}$	8.76	3.69	4.62	5.42	6.11	6.68	7.16	7.56
$5\frac{1}{2}$	10.33	4.19	5.26	6.20	7.00	7.68	8.26	8.74
$5\frac{3}{4}$	12.10	4.73	5.96	7.03	7.96	8.76	9.45	10.02
6	14.07	5.31	6.71	7.93	9.00	9.94	10.74	11.42
$6\frac{1}{4}$	16.27	5.93	7.51	8.90	10.13	11.20	12.13	12.93
$6\frac{1}{2}$	18.70	6.60	8.36	9.94	11.33	12.56	13.63	14.56
$6\frac{3}{4}$	21.38	7.31	9.28	11.05	12.62	14.01	15.24	16.31
7	24.32	8.06	10.25	12.23	13.99	15.56	16.96	18.18
$7\frac{1}{4}$	29.55	8.44	10.84	13.05	15.07	16.91	18.58	20.09
$7\frac{1}{2}$	32.98	9.10	11.70	14.11	16.32	18.34	20.19	21.86
$7\frac{3}{4}$	36.66	9.78	12.59	15.20	17.61	19.82	21.85	23.71
8	40.60	10.47	13.51	16.33	18.94	21.35	23.57	25.61
$8\frac{1}{4}$	44.81	11.19	14.45	17.49	20.31	22.93	25.35	27.58
$8\frac{1}{2}$	49.28	11.92	15.41	18.68	21.72	24.55	27.18	29.60
$8\frac{3}{4}$	54.03	12.67	16.40	19.90	23.17	26.22	29.06	31.69
9	59.07	13.44	17.41	21.15	24.65	27.93	30.98	33.83
$9\frac{1}{4}$	64.40	14.22	18.44	22.42	26.16	29.67	32.96	36.02
$9\frac{1}{2}$	70.02	15.01	19.50	23.73	27.71	31.46	34.97	38.27
$9\frac{3}{4}$	75.94	15.83	20.57	25.06	29.29	33.28	37.04	40.56
10	82.17	16.65	21.66	26.41	30.90	35.14	39.14	42.90

Cast-iron 18 feet long.

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1½ Inch.	1¾ Inch.	1½ Inch.	1¾ Inch.	1¾ Inch.	1¾ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	2.05						
3¾	2.60	2.63					
4	3.23	3.28	3.31				
4¼	3.96	4.03	4.08	4.11			
4½	4.78	4.89	4.97	5.01	5.04		
4¾	5.71	5.86	5.96	6.04	6.09	6.12	
5	6.74	6.93	7.08	7.19	7.26	7.31	7.34
5¼	7.88	8.13	8.33	8.48	8.58	8.66	8.71
5½	9.13	9.45	9.70	9.90	10.05	10.16	10.23
5¾	10.50	10.90	11.22	11.47	11.67	11.81	11.92
6	12.00	12.48	12.87	13.19	13.44	13.64	13.79
6¼	13.61	14.19	14.67	15.07	15.39	15.64	15.83
6½	15.36	16.04	16.62	17.10	17.50	17.82	18.07
6¾	17.24	18.04	18.73	19.30	19.78	20.18	20.50
7	19.26	20.19	20.99	21.67	22.25	22.73	23.12
7¼	21.45	22.66	23.74	24.70	25.54	26.27	26.90
7½	23.38	24.75	25.97	27.06	28.03	28.87	29.61
7¾	25.39	26.92	28.29	29.53	30.62	31.60	32.46
8	27.47	29.17	30.70	32.09	33.33	34.44	35.42
8¼	29.62	31.49	33.20	34.71	36.14	37.39	38.51
8½	31.84	33.89	35.77	37.49	39.04	40.45	41.71
8¾	34.12	36.37	38.43	40.32	42.05	43.61	45.03
9	36.47	38.91	41.17	43.24	45.14	46.88	48.46
9¼	38.87	41.53	43.98	46.25	48.33	50.25	51.99
9½	41.34	44.20	46.86	49.33	51.61	53.71	55.63
9¾	43.86	46.94	49.82	52.49	54.97	57.26	59.37
10	46.44	49.75	52.84	55.73	58.41	60.90	63.21

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in								
Diameter of Pillar outside.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	$1\frac{1}{8}$ Inch.
Inches.								
2	0.26	0.21	0.24					
$2\frac{1}{4}$	0.39	0.30	0.35	0.37				
$2\frac{1}{2}$	0.57	0.41	0.48	0.52	0.55			
$2\frac{3}{4}$	0.80	0.54	0.64	0.71	0.76	0.78		
3	1.10	0.70	0.84	0.93	1.00	1.05	1.07	
$3\frac{1}{4}$	1.46	0.88	1.06	1.20	1.29	1.36	1.41	1.43
$3\frac{1}{2}$	1.89	1.09	1.32	1.50	1.63	1.73	1.80	1.84
$3\frac{3}{4}$	2.42	1.32	1.61	1.85	2.02	2.16	2.26	2.33
4	3.04	1.59	1.95	2.24	2.47	2.65	2.78	2.88
$4\frac{1}{4}$	3.77	1.88	2.32	2.68	2.97	3.20	3.38	3.51
$4\frac{1}{2}$	4.62	2.20	2.73	3.17	3.53	3.82	4.05	4.23
$4\frac{3}{4}$	5.60	2.56	3.18	3.71	4.14	4.50	4.80	5.03
5	6.72	2.95	3.68	4.30	4.83	5.26	5.62	5.91
$5\frac{1}{4}$	7.99	3.37	4.22	4.95	5.57	6.10	6.53	6.89
$5\frac{1}{2}$	9.43	3.82	4.80	5.65	6.38	7.01	7.53	7.97
$5\frac{3}{4}$	11.04	4.32	5.44	6.41	7.26	7.99	8.62	9.14
6	12.84	4.85	6.12	7.24	8.21	9.06	9.79	10.42
$6\frac{1}{4}$	14.84	5.41	6.85	8.12	9.24	10.22	11.06	11.80
$6\frac{1}{2}$	17.06	6.02	7.63	9.06	10.34	11.45	12.43	13.28
$6\frac{3}{4}$	19.50	6.66	8.46	10.07	11.51	12.78	13.90	14.88
7	22.19	7.35	9.35	11.15	12.76	14.20	15.47	16.59
$7\frac{1}{4}$	25.13	8.08	10.29	12.29	14.09	15.71	17.14	18.41
$7\frac{1}{2}$	28.35	8.84	11.29	13.51	15.51	17.31	18.92	20.35
$7\frac{3}{4}$	34.08	9.16	11.80	14.24	16.48	18.55	20.44	22.16
8	37.77	9.83	12.67	15.31	17.75	20.00	22.07	23.97
$8\frac{1}{4}$	41.71	10.51	13.57	16.41	19.05	21.50	23.76	25.83
$8\frac{1}{2}$	45.91	11.21	14.49	17.55	20.40	23.04	25.50	27.76
$8\frac{3}{4}$	50.37	11.92	15.43	18.71	21.78	24.63	27.28	29.74
9	55.11	12.66	16.39	19.90	23.19	26.26	29.12	31.78
$9\frac{1}{4}$	60.12	13.41	17.38	21.12	24.64	27.93	31.01	33.88
$9\frac{1}{2}$	65.42	14.17	18.39	22.37	26.12	29.64	32.94	36.02
$9\frac{3}{4}$	71.00	14.95	19.42	23.65	27.63	31.39	34.91	38.22
10	76.88	15.75	20.47	24.95	29.18	33.17	36.93	40.46

Cast-iron 19 feet long.

if solid, as in the first column, or if hollow, as in the succeed- the respective headings.							
Diameter of Pillar outside.	1¼ Inch.	1⅝ Inch.	1½ Inch.	1⅞ Inch.	1¾ Inch.	1⅞ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	1.87						
3¾	2.37	2.40					
4	2.95	2.99	3.02				
4¼	3.61	3.68	3.72	3.75			
4½	4.36	4.46	4.53	4.57	4.60		
4¾	5.21	5.34	5.44	5.51	5.55	5.58	
5	6.15	6.32	6.46	6.56	6.63	6.67	6.70
5¼	7.19	7.42	7.60	7.73	7.83	7.90	7.94
5½	8.33	8.62	8.85	9.03	9.17	9.26	9.33
5¾	9.58	9.94	10.23	10.46	10.64	10.78	10.87
6	10.94	11.38	11.74	12.03	12.26	12.44	12.58
6¼	12.42	12.94	13.38	13.74	14.03	14.26	14.44
6½	14.01	14.64	15.16	15.60	15.96	16.25	16.48
6¾	15.73	16.46	17.08	17.61	18.04	18.40	18.70
7	17.56	18.41	19.14	19.77	20.29	20.73	21.09
7¼	19.53	20.51	21.36	22.09	22.71	23.24	23.68
7½	21.63	22.74	23.72	24.57	25.30	25.93	26.45
7¾	23.73	25.14	26.42	27.56	28.57	29.47	30.26
8	25.70	27.27	28.70	29.98	31.13	32.15	33.06
8¼	27.74	29.48	31.06	32.49	33.78	34.94	35.97
8½	29.84	31.76	33.50	35.09	36.54	37.84	39.00
8¾	32.02	34.11	36.03	37.79	39.39	40.84	42.15
9	34.25	36.53	38.63	40.56	42.33	43.94	45.40
9¼	36.55	39.02	41.31	43.42	45.36	47.14	48.76
9½	38.90	41.58	44.06	46.36	48.48	50.44	52.23
9¾	41.31	44.20	46.88	49.38	51.69	53.82	55.79
10	43.78	46.88	49.78	52.47	54.98	57.30	59.45

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in								
Diameter of Pillar outside. Inches.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	$1\frac{1}{8}$ Inch.
2	0.24	0.19	0.22					
$2\frac{1}{4}$	0.36	0.28	0.32	0.34				
$2\frac{1}{2}$	0.53	0.38	0.44	0.48	0.51			
$2\frac{3}{4}$	0.74	0.50	0.59	0.65	0.69	0.72		
3	1.00	0.64	0.77	0.86	0.92	0.96	0.98	
$3\frac{1}{4}$	1.33	0.81	0.97	1.10	1.19	1.25	1.29	1.31
$3\frac{1}{2}$	1.74	1.00	1.21	1.37	1.50	1.59	1.65	1.69
$3\frac{3}{4}$	2.22	1.21	1.48	1.69	1.86	1.98	2.07	2.13
4	2.79	1.45	1.78	2.05	2.26	2.43	2.55	2.64
$4\frac{1}{4}$	3.46	1.72	2.12	2.45	2.72	2.93	3.10	3.22
$4\frac{1}{2}$	4.24	2.02	2.50	2.90	3.23	3.50	3.71	3.88
$4\frac{3}{4}$	5.13	2.34	2.92	3.40	3.80	4.13	4.40	4.61
5	6.16	2.70	3.37	3.94	4.42	4.82	5.15	5.42
$5\frac{1}{4}$	7.32	3.09	3.86	4.53	5.11	5.59	5.99	6.32
$5\frac{1}{2}$	8.64	3.51	4.40	5.18	5.85	6.42	6.90	7.30
$5\frac{3}{4}$	10.12	3.96	4.98	5.88	6.66	7.33	7.90	8.38
6	11.77	4.44	5.61	6.63	7.53	8.31	8.98	9.55
$6\frac{1}{4}$	13.60	4.96	6.28	7.44	8.47	9.36	10.14	10.81
$6\frac{1}{2}$	15.63	5.52	6.99	8.31	9.47	10.50	11.39	12.17
$6\frac{3}{4}$	17.87	6.11	7.76	9.23	10.55	11.71	12.74	13.64
7	20.34	6.74	8.57	10.22	11.70	13.01	14.18	15.20
$7\frac{1}{4}$	23.03	7.40	9.43	11.27	12.92	14.39	15.71	16.87
$7\frac{1}{2}$	25.98	8.11	10.35	12.38	14.21	15.86	17.34	18.66
$7\frac{3}{4}$	29.19	8.85	11.31	13.55	15.59	17.42	19.07	20.55
8	32.67	9.63	12.33	14.80	17.04	19.07	20.90	22.55
$8\frac{1}{4}$	38.92	9.89	12.76	15.43	17.90	20.19	22.30	24.24
$8\frac{1}{2}$	42.87	10.55	13.63	16.51	19.18	21.66	23.96	26.08
$8\frac{3}{4}$	47.07	11.24	14.53	17.62	20.50	23.18	25.66	27.96
9	51.53	11.94	15.46	18.76	21.85	24.73	27.42	29.91
$9\frac{1}{4}$	56.25	12.66	16.41	19.93	23.23	26.33	29.22	31.91
$9\frac{1}{2}$	61.24	13.39	17.37	21.12	24.65	27.96	31.06	33.96
$9\frac{3}{4}$	66.52	14.14	18.36	22.35	26.10	29.64	32.95	36.06
10	72.07	14.90	19.37	23.59	27.58	31.35	34.88	38.21

Cast-iron 20 feet long.

if solid, as in the first column, or if hollow, as in the succeeding the respective headings.

Diameter of Pillar outside. Inches.	1 $\frac{1}{4}$ Inch.	1 $\frac{3}{8}$ Inch.	1 $\frac{1}{2}$ Inch.	1 $\frac{5}{8}$ Inch.	1 $\frac{3}{4}$ Inch.	1 $\frac{7}{8}$ Inch.	2 Inch.
2							
2 $\frac{1}{4}$							
2 $\frac{1}{2}$							
2 $\frac{3}{4}$							
3							
3 $\frac{1}{4}$							
3 $\frac{1}{2}$	1.72						
3 $\frac{3}{4}$	2.17	2.20					
4	2.70	2.74	2.77				
4 $\frac{1}{4}$	3.31	3.37	3.41	3.44			
4 $\frac{1}{2}$	4.00	4.09	4.15	4.19	4.22		
4 $\frac{3}{4}$	4.77	4.90	4.99	5.05	5.09	5.11	
5	5.63	5.80	5.92	6.01	6.07	6.11	6.14
5 $\frac{1}{4}$	6.59	6.80	6.96	7.09	7.18	7.24	7.28
5 $\frac{1}{2}$	7.63	7.90	8.11	8.28	8.40	8.49	8.55
5 $\frac{3}{4}$	8.78	9.11	9.38	9.59	9.75	9.88	9.97
6	10.03	10.43	10.76	11.03	11.24	11.40	11.53
6 $\frac{1}{4}$	11.38	11.86	12.27	12.60	12.86	13.07	13.24
6 $\frac{1}{2}$	12.84	13.41	13.90	14.30	14.63	14.89	15.11
6 $\frac{3}{4}$	14.41	15.08	15.65	16.14	16.54	16.87	17.13
7	16.10	16.88	17.55	18.12	18.60	19.00	19.33
7 $\frac{1}{4}$	17.90	18.80	19.57	20.24	20.82	21.30	21.70
7 $\frac{1}{2}$	19.82	20.85	21.74	22.52	23.19	23.76	24.24
7 $\frac{3}{4}$	21.86	23.03	24.05	24.95	25.73	26.40	26.97
8	24.03	25.34	26.51	27.53	28.43	29.21	29.88
8 $\frac{1}{4}$	26.02	27.64	29.11	30.44	31.64	32.72	33.67
8 $\frac{1}{2}$	28.02	29.81	31.43	32.91	34.25	35.46	36.54
8 $\frac{3}{4}$	30.09	32.04	33.83	35.47	36.96	38.31	39.53
9	32.22	34.35	36.31	38.11	39.76	41.26	42.62
9 $\frac{1}{4}$	34.41	36.72	38.86	40.84	42.65	44.30	45.81
9 $\frac{1}{2}$	36.66	39.16	41.49	43.64	45.62	47.44	49.11
9 $\frac{3}{4}$	38.96	41.67	44.18	46.52	48.68	50.67	52.50
10	41.32	44.23	46.95	49.48	51.82	53.99	56.00

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support,
ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	1 $\frac{1}{8}$ Inch.
Inches.								
2	0.22	0.18	0.20					
2 $\frac{1}{4}$	0.33	0.25	0.29	0.31				
2 $\frac{1}{2}$	0.48	0.35	0.40	0.44	0.46			
2 $\frac{3}{4}$	0.68	0.46	0.54	0.60	0.64	0.66		
3	0.92	0.59	0.71	0.79	0.85	0.88	0.91	
3 $\frac{1}{4}$	1.23	0.74	0.89	1.01	1.09	1.15	1.19	1.21
3 $\frac{1}{2}$	1.60	0.92	1.11	1.26	1.38	1.46	1.52	1.56
3 $\frac{3}{4}$	2.04	1.12	1.36	1.56	1.71	1.82	1.90	1.96
4	2.57	1.34	1.64	1.89	2.08	2.23	2.35	2.43
4 $\frac{1}{4}$	3.18	1.59	1.96	2.26	2.50	2.70	2.85	2.96
4 $\frac{1}{2}$	3.90	1.86	2.30	2.67	2.97	3.22	3.42	3.57
4 $\frac{3}{4}$	4.72	2.16	2.68	3.13	3.50	3.80	4.05	4.24
5	5.67	2.48	3.10	3.63	4.07	4.44	4.74	4.99
5 $\frac{1}{4}$	6.74	2.84	3.56	4.17	4.70	5.14	5.51	5.82
5 $\frac{1}{2}$	7.95	3.23	4.05	4.77	5.38	5.91	6.35	6.72
5 $\frac{3}{4}$	9.31	3.64	4.58	5.41	6.13	6.74	7.27	7.71
6	10.83	4.09	5.16	6.10	6.93	7.64	8.26	8.79
6 $\frac{1}{4}$	12.52	4.57	5.78	6.85	7.79	8.62	9.33	9.95
6 $\frac{1}{2}$	14.39	5.08	6.44	7.65	8.72	9.66	10.49	11.20
6 $\frac{3}{4}$	16.45	5.62	7.14	8.50	9.71	10.78	11.72	12.55
7	18.72	6.20	7.89	9.41	10.77	11.98	13.05	13.99
7 $\frac{1}{4}$	21.20	6.81	8.68	10.37	11.89	13.25	14.46	15.53
7 $\frac{1}{2}$	23.91	7.46	9.52	11.39	13.08	14.60	15.96	17.17
7 $\frac{3}{4}$	26.86	8.15	10.41	12.48	14.35	16.03	17.55	18.91
8	30.07	8.87	11.35	13.62	15.68	17.55	19.24	20.76
8 $\frac{1}{4}$	35.54	9.63	12.34	14.82	17.09	19.15	21.02	22.71
8 $\frac{1}{2}$	40.12	9.95	12.85	15.56	18.07	20.40	22.55	24.53
8 $\frac{3}{4}$	44.07	10.61	13.71	16.62	19.32	21.84	24.17	26.33
9	48.28	11.28	14.60	17.71	20.61	23.32	25.85	28.19
9 $\frac{1}{4}$	52.73	11.96	15.50	18.82	21.94	24.85	27.57	30.09
9 $\frac{1}{2}$	57.45	12.67	16.43	19.97	23.30	26.41	29.33	32.05
9 $\frac{3}{4}$	62.43	13.39	17.38	21.14	24.69	28.02	31.14	34.06
10	67.68	14.12	18.35	22.34	26.11	29.66	32.99	36.12

Cast-iron **21** feet long.

if solid, as in the first column, or if hollow, as in the succeed- the respective headings.							
Diameter of Pillar outside.	1½ Inch.	1¾ Inch.	1½ Inch.	1¾ Inch.	1¾ Inch.	1¾ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	1.58						
3¾	2.00	2.02					
4	2.49	2.53	2.55				
4¼	3.05	3.10	3.14	3.16			
4½	3.68	3.76	3.82	3.86	3.88		
4¾	4.39	4.51	4.59	4.65	4.68	4.71	
5	5.18	5.34	5.45	5.53	5.59	5.63	5.65
5¼	6.06	6.26	6.41	6.52	6.60	6.66	6.70
5½	7.03	7.27	7.47	7.62	7.73	7.81	7.87
5¾	8.08	8.38	8.63	8.83	8.98	9.09	9.17
6	9.23	9.60	9.90	10.15	10.34	10.50	10.61
6¼	10.48	10.92	11.29	11.59	11.84	12.03	12.18
6½	11.82	12.35	12.79	13.16	13.46	13.71	13.90
6¾	13.27	13.88	14.41	14.85	15.22	15.52	15.77
7	14.82	15.53	16.15	16.68	17.12	17.49	17.79
7¼	16.47	17.30	18.02	18.63	19.16	19.60	19.97
7½	18.24	19.19	20.01	20.73	21.34	21.87	22.31
7¾	20.12	21.19	22.14	22.96	23.68	24.30	24.82
8	22.12	23.33	24.40	25.34	26.17	26.88	27.50
8¼	24.23	25.59	26.80	27.87	28.81	29.64	30.35
8½	26.36	28.02	29.54	30.92	32.17	33.30	34.30
8¾	28.32	30.15	31.83	33.36	34.74	36.00	37.13
9	30.35	32.35	34.19	35.87	37.40	38.80	40.07
9¼	32.44	34.61	36.62	38.46	40.15	41.70	43.11
9½	34.59	36.94	39.12	41.14	42.99	44.69	46.25
9¾	36.79	39.34	41.70	43.89	45.91	47.77	49.48
10	39.06	41.79	44.34	46.71	48.91	50.95	52.82

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in								
Diameter of Pillar outside.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	$1\frac{1}{8}$ Inch.
Inches.								
2	0.20	0.16	0.19					
$2\frac{1}{4}$	0.31	0.23	0.27	0.29				
$2\frac{1}{2}$	0.45	0.32	0.37	0.41	0.43			
$2\frac{3}{4}$	0.63	0.42	0.50	0.55	0.59	0.61		
3	0.85	0.55	0.65	0.73	0.78	0.82	0.84	
$3\frac{1}{4}$	1.13	0.69	0.83	0.93	1.01	1.06	1.10	1.12
$3\frac{1}{2}$	1.48	0.85	1.03	1.17	1.27	1.35	1.40	1.44
$3\frac{3}{4}$	1.89	1.03	1.26	1.44	1.58	1.68	1.76	1.81
4	2.37	1.24	1.52	1.74	1.92	2.06	2.18	2.25
$4\frac{1}{4}$	2.94	1.46	1.81	2.09	2.31	2.49	2.63	2.74
$4\frac{1}{2}$	3.60	1.72	2.13	2.47	2.75	2.98	3.16	3.30
$4\frac{3}{4}$	4.37	1.99	2.48	2.89	3.23	3.51	3.74	3.92
5	5.24	2.30	2.87	3.35	3.76	4.10	4.38	4.61
$5\frac{1}{4}$	6.23	2.62	3.29	3.86	4.34	4.75	5.09	5.37
$5\frac{1}{2}$	7.35	2.98	3.74	4.40	4.97	5.46	5.87	6.21
$5\frac{3}{4}$	8.60	3.36	4.24	5.00	5.66	6.23	6.72	7.13
6	10.01	3.78	4.77	5.64	6.40	7.06	7.63	8.12
$6\frac{1}{4}$	11.57	4.22	5.34	6.33	7.20	7.96	8.62	9.19
$6\frac{1}{2}$	13.29	4.69	5.95	7.07	8.06	8.93	9.69	10.35
$6\frac{3}{4}$	15.20	5.19	6.60	7.85	8.97	9.96	10.83	11.60
7	17.29	5.73	7.29	8.69	9.95	11.07	12.06	12.93
$7\frac{1}{4}$	19.59	6.29	8.02	9.58	10.99	12.24	13.36	14.35
$7\frac{1}{2}$	22.09	6.89	8.80	10.53	12.09	13.49	14.75	15.86
$7\frac{3}{4}$	24.82	7.53	9.62	11.53	13.25	14.82	16.22	17.47
8	27.78	8.19	10.49	12.58	14.49	16.22	17.78	19.18
$8\frac{1}{4}$	30.99	8.90	11.40	13.69	15.79	17.70	19.42	20.98
$8\frac{1}{2}$	34.45	9.63	12.36	14.86	17.16	19.25	21.16	22.89
$8\frac{3}{4}$	38.19	10.41	13.37	16.09	18.60	20.89	22.99	24.89
9	45.32	10.67	13.80	16.73	19.47	22.03	24.40	26.60
$9\frac{1}{4}$	49.53	11.32	14.67	17.80	20.74	23.49	26.05	28.43
$9\frac{1}{2}$	53.99	12.00	15.56	18.90	22.04	24.98	27.73	30.30
$9\frac{3}{4}$	58.70	12.69	16.46	20.02	23.37	26.52	29.47	32.22
10	63.68	13.39	17.40	21.17	24.74	28.09	31.24	34.20

Cast-iron 22 feet long.

if solid, as in the first column, or if hollow, as in the succeed- the respective headings.							
Diameter of Pillar outside.	1 $\frac{1}{4}$ Inch.	1 $\frac{3}{8}$ Inch.	1 $\frac{1}{2}$ Inch.	1 $\frac{5}{8}$ Inch.	1 $\frac{3}{4}$ Inch.	1 $\frac{7}{8}$ Inch.	2 Inch.
Inches.							
2							
2 $\frac{1}{4}$							
2 $\frac{1}{2}$							
2 $\frac{3}{4}$							
3							
3 $\frac{1}{4}$							
3 $\frac{1}{2}$	1.46						
3 $\frac{3}{4}$	1.85	1.87					
4	2.30	2.33	2.35				
4 $\frac{1}{4}$	2.82	2.87	2.90	2.92			
4 $\frac{1}{2}$	3.40	3.48	3.53	3.56	3.59		
4 $\frac{3}{4}$	4.06	4.16	4.24	4.29	4.33	4.35	
5	4.79	4.93	5.04	5.11	5.16	5.20	5.22
5 $\frac{1}{4}$	5.60	5.78	5.92	6.03	6.10	6.16	6.19
5 $\frac{1}{2}$	6.49	6.72	6.90	7.04	7.14	7.22	7.27
5 $\frac{3}{4}$	7.47	7.75	7.97	8.15	8.29	8.40	8.48
6	8.53	8.87	9.15	9.38	9.56	9.70	9.80
6 $\frac{1}{4}$	9.68	10.09	10.43	10.71	10.94	11.12	11.26
6 $\frac{1}{2}$	10.92	11.41	11.82	12.16	12.44	12.67	12.85
6 $\frac{3}{4}$	12.26	12.83	13.31	13.72	14.06	14.34	14.57
7	13.69	14.35	14.92	15.41	15.82	16.16	16.44
7 $\frac{1}{4}$	15.22	15.98	16.65	17.22	17.70	18.11	18.45
7 $\frac{1}{2}$	16.86	17.73	18.49	19.15	19.72	20.21	20.62
7 $\frac{3}{4}$	18.59	19.58	20.45	21.22	21.88	22.45	22.93
8	20.44	21.55	22.54	23.42	24.18	24.84	25.41
8 $\frac{1}{4}$	22.39	23.64	24.76	25.75	26.62	27.39	28.05
8 $\frac{1}{2}$	24.45	25.85	27.11	28.22	29.22	30.09	30.85
8 $\frac{3}{4}$	26.62	28.18	29.58	30.84	31.96	32.95	33.82
9	28.64	30.51	32.23	33.81	35.25	36.55	37.73
9 $\frac{1}{4}$	30.63	32.67	34.55	36.28	37.87	39.31	40.63
9 $\frac{1}{2}$	32.68	34.90	36.95	38.83	40.57	42.16	43.62
9 $\frac{3}{4}$	34.79	37.19	39.41	41.46	43.36	45.11	46.71
10	36.96	39.54	41.94	44.17	46.23	48.14	49.89

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support,
ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	$1\frac{1}{8}$ Inch.
Inches.								
2	0.19	0.15	0.17					
$2\frac{1}{4}$	0.29	0.22	0.25	0.27				
$2\frac{1}{2}$	0.41	0.30	0.35	0.38	0.40			
$2\frac{3}{4}$	0.58	0.39	0.46	0.51	0.55	0.57		
3	0.79	0.51	0.60	0.67	0.72	0.76	0.78	
$3\frac{1}{4}$	1.05	0.64	0.77	0.86	0.93	0.98	1.02	1.04
$3\frac{1}{2}$	1.37	0.79	0.95	1.08	1.18	1.25	1.30	1.33
$3\frac{3}{4}$	1.75	0.96	1.17	1.33	1.46	1.56	1.63	1.68
4	2.20	1.15	1.41	1.62	1.78	1.91	2.01	2.08
$4\frac{1}{4}$	2.73	1.36	1.67	1.93	2.14	2.31	2.44	2.54
$4\frac{1}{2}$	3.34	1.59	1.97	2.29	2.55	2.76	2.93	3.06
$4\frac{3}{4}$	4.05	1.85	2.30	2.68	3.00	3.26	3.47	3.63
5	4.86	2.13	2.66	3.11	3.49	3.80	4.06	4.27
$5\frac{1}{4}$	5.77	2.43	3.05	3.58	4.03	4.41	4.72	4.98
$5\frac{1}{2}$	6.81	2.76	3.47	4.08	4.61	5.06	5.44	5.76
$5\frac{3}{4}$	7.98	3.12	3.93	4.63	5.25	5.78	6.23	6.61
6	9.28	3.50	4.42	5.23	5.94	6.55	7.08	7.53
$6\frac{1}{4}$	10.72	3.91	4.95	5.87	6.68	7.38	8.00	8.52
$6\frac{1}{2}$	12.33	4.35	5.51	6.55	7.47	8.28	8.98	9.60
$6\frac{3}{4}$	14.09	4.82	6.12	7.28	8.32	9.24	10.04	10.75
7	16.03	5.31	6.76	8.06	9.22	10.26	11.18	11.99
$7\frac{1}{4}$	18.16	5.84	7.44	8.88	10.19	11.35	12.39	13.31
$7\frac{1}{2}$	20.49	6.39	8.16	9.76	11.21	12.51	13.67	14.71
$7\frac{3}{4}$	23.01	6.98	8.92	10.69	12.29	13.74	15.04	16.20
8	25.76	7.60	9.72	11.67	13.43	15.03	16.48	17.78
$8\frac{1}{4}$	28.73	8.25	10.57	12.70	14.64	16.41	18.01	19.46
$8\frac{1}{2}$	31.95	8.93	11.46	13.78	15.91	17.85	19.62	21.22
$8\frac{3}{4}$	35.41	9.65	12.39	14.92	17.25	19.37	21.31	23.08
9	39.13	10.40	13.37	16.12	18.65	20.97	23.10	25.04
$9\frac{1}{4}$	46.61	10.73	13.89	16.86	19.64	22.23	24.64	26.89
$9\frac{1}{2}$	50.83	11.38	14.75	17.91	20.88	23.66	26.26	28.68
$9\frac{3}{4}$	55.30	12.04	15.62	18.99	22.16	25.13	27.92	30.52
10	60.01	12.72	16.51	20.09	23.47	26.64	29.62	32.41

Cast-iron 23 feet long.

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1 $\frac{1}{4}$ Inch.	1 $\frac{3}{8}$ Inch.	1 $\frac{1}{2}$ Inch.	1 $\frac{5}{8}$ Inch.	1 $\frac{3}{4}$ Inch.	1 $\frac{7}{8}$ Inch.	2 Inch.
Inches.							
2							
2 $\frac{1}{4}$							
2 $\frac{1}{2}$							
2 $\frac{3}{4}$							
3							
3 $\frac{1}{4}$							
3 $\frac{1}{2}$	1.35						
3 $\frac{3}{4}$	1.71	1.73					
4	2.13	2.16	2.18				
4 $\frac{1}{4}$	2.61	2.66	2.69	2.71			
4 $\frac{1}{2}$	3.15	3.22	3.27	3.31	3.32		
4 $\frac{3}{4}$	3.76	3.86	3.93	3.98	4.01	4.03	
5	4.44	4.57	4.67	4.74	4.79	4.82	4.84
5 $\frac{1}{4}$	5.19	5.36	5.49	5.59	5.66	5.71	5.74
5 $\frac{1}{2}$	6.02	6.23	6.40	6.53	6.62	6.69	6.74
5 $\frac{3}{4}$	6.92	7.18	7.39	7.56	7.69	7.79	7.86
6	7.91	8.22	8.48	8.69	8.86	8.99	9.09
6 $\frac{1}{4}$	8.97	9.35	9.67	9.93	10.14	10.31	10.44
6 $\frac{1}{2}$	10.13	10.58	10.96	11.27	11.53	11.74	11.91
6 $\frac{3}{4}$	11.37	11.89	12.34	12.72	13.04	13.30	13.51
7	12.69	13.31	13.84	14.29	14.67	14.98	15.24
7 $\frac{1}{4}$	14.11	14.82	15.43	15.96	16.41	16.79	17.11
7 $\frac{1}{2}$	15.63	16.44	17.14	17.76	18.29	18.74	19.12
7 $\frac{3}{4}$	17.24	18.16	18.97	19.67	20.29	20.81	21.26
8	18.95	19.98	20.90	21.71	22.42	23.03	23.56
8 $\frac{1}{4}$	20.76	21.92	22.96	23.88	24.68	25.39	26.01
8 $\frac{1}{2}$	22.67	23.97	25.13	26.17	27.09	27.90	28.60
8 $\frac{3}{4}$	24.68	26.13	27.43	28.60	29.63	30.55	31.36
9	26.81	28.41	29.85	31.16	32.32	33.36	34.28
9 $\frac{1}{4}$	28.96	30.88	32.65	34.28	35.76	37.12	38.35
9 $\frac{1}{2}$	30.93	33.01	34.94	36.71	38.34	39.84	41.20
9 $\frac{3}{4}$	32.94	35.20	37.29	39.22	41.01	42.65	44.15
10	35.02	37.45	39.71	41.81	43.75	45.54	47.19

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support,
ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	$1\frac{1}{8}$ Inch.
Inches.								
2	0.17	0.14	0.16					
$2\frac{1}{4}$	0.26	0.20	0.23	0.25				
$2\frac{1}{2}$	0.39	0.28	0.32	0.35	0.37			
$2\frac{3}{4}$	0.54	0.37	0.43	0.48	0.51	0.53		
3	0.74	0.47	0.56	0.63	0.67	0.70	0.72	
$3\frac{1}{4}$	0.98	0.59	0.71	0.80	0.87	0.92	0.95	0.96
$3\frac{1}{2}$	1.27	0.73	0.89	1.01	1.10	1.16	1.21	1.24
$3\frac{3}{4}$	1.63	0.89	1.09	1.24	1.36	1.45	1.52	1.56
4	2.05	1.07	1.31	1.50	1.66	1.78	1.87	1.94
$4\frac{1}{4}$	2.54	1.26	1.56	1.80	2.00	2.15	2.27	2.36
$4\frac{1}{2}$	3.11	1.48	1.83	2.13	2.37	2.57	2.72	2.84
$4\frac{3}{4}$	3.76	1.72	2.14	2.49	2.79	3.03	3.22	3.38
5	4.52	1.98	2.47	2.89	3.24	3.54	3.78	3.98
$5\frac{1}{4}$	5.37	2.26	2.83	3.33	3.74	4.10	4.39	4.63
$5\frac{1}{2}$	6.34	2.57	3.23	3.80	4.29	4.71	5.06	5.36
$5\frac{3}{4}$	7.42	2.90	3.65	4.31	4.88	5.37	5.79	6.15
6	8.63	3.26	4.11	4.86	5.52	6.09	6.58	7.00
$6\frac{1}{4}$	9.97	3.64	4.60	5.46	6.21	6.87	7.44	7.93
$6\frac{1}{2}$	11.47	4.05	5.13	6.09	6.95	7.70	8.36	8.93
$6\frac{3}{4}$	13.11	4.48	5.69	6.77	7.74	8.59	9.34	10.00
7	14.92	4.94	6.29	7.50	8.58	9.54	10.40	11.15
$7\frac{1}{4}$	16.89	5.43	6.92	8.27	9.48	10.56	11.52	12.38
$7\frac{1}{2}$	19.05	5.95	7.59	9.08	10.43	11.64	12.72	13.68
$7\frac{3}{4}$	21.41	6.49	8.30	9.94	11.43	12.78	13.99	15.07
8	23.96	7.07	9.05	10.85	12.50	13.99	15.33	16.54
$8\frac{1}{4}$	26.73	7.67	9.83	11.81	13.62	15.26	16.75	18.10
$8\frac{1}{2}$	29.72	8.31	10.66	12.82	14.80	16.61	18.25	19.74
$8\frac{3}{4}$	32.94	8.97	11.53	13.88	16.04	18.02	19.83	21.47
9	36.40	9.67	12.44	14.99	17.35	19.51	21.48	23.29
$9\frac{1}{4}$	40.12	10.40	13.39	16.16	18.71	21.06	23.22	25.20
$9\frac{1}{2}$	44.10	11.17	14.39	17.37	20.14	22.69	25.05	27.21
$9\frac{3}{4}$	52.18	11.44	14.83	18.03	21.03	23.85	26.48	28.94
10	56.65	12.09	15.69	19.09	22.29	25.29	28.11	30.75

Cast-iron 24 feet long.

if solid, as in the first column, or if hollow, as in the succeeding the respective headings.

Diameter of Pillar outside.	1 $\frac{1}{4}$ Inch.	1 $\frac{3}{8}$ Inch.	1 $\frac{1}{2}$ Inch.	1 $\frac{5}{8}$ Inch.	1 $\frac{3}{4}$ Inch.	1 $\frac{7}{8}$ Inch.	2 Inch.
Inches.							
2							
2 $\frac{1}{4}$							
2 $\frac{1}{2}$							
2 $\frac{3}{4}$							
3							
3 $\frac{1}{4}$							
3 $\frac{1}{2}$	1.26						
3 $\frac{3}{4}$	1.59	1.61					
4	1.98	2.01	2.03				
4 $\frac{1}{4}$	2.43	2.47	2.50	2.52			
4 $\frac{1}{2}$	2.93	3.00	3.04	3.07	3.09		
4 $\frac{3}{4}$	3.50	3.59	3.66	3.70	3.73	3.75	
5	4.13	4.25	4.34	4.41	4.45	4.48	4.50
5 $\frac{1}{4}$	4.83	4.99	5.11	5.20	5.26	5.31	5.34
5 $\frac{1}{2}$	5.60	5.79	5.95	6.07	6.16	6.23	6.27
5 $\frac{3}{4}$	6.44	6.68	6.88	7.03	7.15	7.24	7.31
6	7.36	7.65	7.89	8.09	8.24	8.36	8.45
6 $\frac{1}{4}$	8.35	8.70	9.00	9.24	9.43	9.59	9.71
6 $\frac{1}{2}$	9.42	9.84	10.19	10.49	10.73	10.92	11.08
6 $\frac{3}{4}$	10.57	11.06	11.48	11.84	12.13	12.37	12.57
7	11.81	12.38	12.87	13.29	13.64	13.94	14.18
7 $\frac{1}{4}$	13.13	13.79	14.36	14.85	15.27	15.62	15.92
7 $\frac{1}{2}$	14.54	15.29	15.95	16.52	17.01	17.43	17.78
7 $\frac{3}{4}$	16.04	16.89	17.64	18.30	18.97	19.36	19.78
8	17.63	18.59	19.44	20.20	20.85	21.42	21.92
8 $\frac{1}{4}$	19.31	20.39	21.36	22.21	22.96	23.62	24.19
8 $\frac{1}{2}$	21.09	22.30	23.38	24.34	25.20	25.95	26.61
8 $\frac{3}{4}$	22.96	24.31	25.52	26.60	27.56	28.42	29.17
9	24.93	26.43	27.77	28.98	30.06	31.03	31.88
9 $\frac{1}{4}$	27.01	28.65	30.14	31.49	32.70	33.78	34.75
9 $\frac{1}{2}$	29.19	30.99	32.64	34.13	35.47	36.68	37.77
9 $\frac{3}{4}$	31.23	33.36	35.33	37.15	38.84	40.38	41.79
10	33.22	35.51	37.65	39.63	41.46	43.15	44.70

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in								
Diameter of Pillar outside.	Solid.	$\frac{3}{4}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{3}{8}$ Inch.	$\frac{1}{4}$ Inch.	$\frac{1}{8}$ Inch.	1 Inch.	$1\frac{1}{2}$ Inch.
Inches.								
2	0.16	0.13	0.15					
$2\frac{1}{4}$	0.25	0.19	0.22	0.23				
$2\frac{1}{2}$	0.36	0.26	0.30	0.33	0.35			
$2\frac{3}{4}$	0.50	0.34	0.40	0.45	0.47	0.49		
3	0.69	0.44	0.52	0.59	0.63	0.66	0.67	
$3\frac{1}{4}$	0.91	0.55	0.66	0.75	0.81	0.85	0.88	0.90
$3\frac{1}{2}$	1.19	0.68	0.83	0.94	1.02	1.09	1.13	1.16
$3\frac{3}{4}$	1.52	0.83	1.01	1.16	1.27	1.35	1.42	1.46
4	1.91	1.00	1.22	1.40	1.55	1.66	1.75	1.81
$4\frac{1}{4}$	2.37	1.18	1.45	1.68	1.86	2.01	2.12	2.20
$4\frac{1}{2}$	2.90	1.38	1.71	1.99	2.21	2.39	2.54	2.65
$4\frac{3}{4}$	3.51	1.60	1.99	2.32	2.60	2.83	3.01	3.15
5	4.21	1.85	2.31	2.70	3.03	3.30	3.53	3.71
$5\frac{1}{4}$	5.01	2.11	2.64	3.10	3.49	3.82	4.10	4.32
$5\frac{1}{2}$	5.91	2.40	3.01	3.54	4.00	4.39	4.72	5.00
$5\frac{3}{4}$	6.92	2.71	3.41	4.02	4.55	5.01	5.40	5.73
6	8.05	3.04	3.84	4.54	5.15	5.68	6.14	6.53
$6\frac{1}{4}$	9.31	3.39	4.29	5.09	5.79	6.41	6.94	7.40
$6\frac{1}{2}$	10.70	3.77	4.79	5.68	6.48	7.18	7.80	8.33
$6\frac{3}{4}$	12.23	4.18	5.31	6.32	7.22	8.01	8.72	9.33
7	13.92	4.61	5.86	6.99	8.00	8.90	9.70	10.40
$7\frac{1}{4}$	15.76	5.06	6.46	7.71	8.84	9.85	10.75	11.55
$7\frac{1}{2}$	17.78	5.55	7.08	8.47	9.73	10.86	11.87	12.77
$7\frac{3}{4}$	19.97	6.06	7.74	9.27	10.67	11.92	13.05	14.06
8	22.36	6.59	8.44	10.13	11.66	13.05	14.30	15.43
$8\frac{1}{4}$	24.94	7.16	9.17	11.02	12.71	14.24	15.63	16.88
$8\frac{1}{2}$	27.72	7.75	9.94	11.96	13.81	15.49	17.03	18.42
$8\frac{3}{4}$	30.73	8.37	10.76	12.95	14.97	16.81	18.50	20.03
9	33.96	9.02	11.60	13.99	16.18	18.20	20.04	21.73
$9\frac{1}{4}$	37.43	9.71	12.49	15.07	17.46	19.65	21.67	23.51
$9\frac{1}{2}$	41.15	10.42	13.42	16.21	18.79	21.17	23.37	25.38
$9\frac{3}{4}$	45.12	11.16	14.39	17.40	20.18	22.77	25.15	27.34
10	49.36	11.93	15.40	18.64	21.64	24.43	27.01	29.39

Cast-iron 25 feet long.

if solid, as in the first column, or if hollow, as in the succeed- the respective headings.							
Diameter of Pillar outside.	1 $\frac{1}{4}$ Inch.	1 $\frac{3}{8}$ Inch.	1 $\frac{1}{2}$ Inch.	1 $\frac{5}{8}$ Inch.	1 $\frac{3}{4}$ Inch.	1 $\frac{7}{8}$ Inch.	2 Inch.
Inches.							
2							
2 $\frac{1}{4}$							
2 $\frac{1}{2}$							
2 $\frac{3}{4}$							
3							
3 $\frac{1}{4}$							
3 $\frac{1}{2}$	1.17						
3 $\frac{3}{4}$	1.49	1.50					
4	1.85	1.88	1.89				
4 $\frac{1}{4}$	2.27	2.31	2.34	2.35			
4 $\frac{1}{2}$	2.74	2.80	2.84	2.87	2.88		
4 $\frac{3}{4}$	3.26	3.35	3.41	3.45	3.48	3.50	
5	3.85	3.97	4.05	4.11	4.16	4.18	4.20
5 $\frac{1}{4}$	4.51	4.65	4.76	4.85	4.91	4.95	4.98
5 $\frac{1}{2}$	5.22	5.41	5.55	5.66	5.75	5.81	5.85
5 $\frac{3}{4}$	6.01	6.23	6.42	6.56	6.67	6.76	6.82
6	6.86	7.14	7.36	7.55	7.69	7.80	7.89
6 $\frac{1}{4}$	7.79	8.12	8.39	8.62	8.80	8.95	9.06
6 $\frac{1}{2}$	8.79	9.18	9.51	9.78	10.01	10.19	10.34
6 $\frac{3}{4}$	9.86	10.32	10.71	11.04	11.32	11.54	11.72
7	11.02	11.55	12.01	12.40	12.73	13.00	13.23
7 $\frac{1}{4}$	12.25	12.86	13.39	13.85	14.24	14.57	14.85
7 $\frac{1}{2}$	13.56	14.26	14.88	15.41	15.87	16.26	16.59
7 $\frac{3}{4}$	14.96	15.76	16.46	17.07	17.60	18.06	18.45
8	16.44	17.34	18.14	18.84	19.46	19.99	20.45
8 $\frac{1}{4}$	18.01	19.02	19.92	20.72	21.42	22.04	22.57
8 $\frac{1}{2}$	19.67	20.80	21.81	22.71	23.51	24.21	24.82
8 $\frac{3}{4}$	21.42	22.68	23.81	24.82	25.72	26.51	27.21
9	23.26	24.65	25.91	27.04	28.05	28.95	29.74
9 $\frac{1}{4}$	25.20	26.73	28.12	29.38	30.51	31.52	32.42
9 $\frac{1}{2}$	27.23	28.92	30.45	31.84	33.09	34.22	35.23
9 $\frac{3}{4}$	29.36	31.20	32.89	34.42	35.81	37.07	38.20
10	31.39	33.60	35.45	37.13	38.67	40.06	41.31

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in								
Diameter of Pillar outside.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	1 $\frac{1}{8}$ Inch.
Inches.								
2	0.15	0.12	0.14					
2 $\frac{1}{4}$	0.23	0.18	0.20	0.22				
2 $\frac{1}{2}$	0.34	0.24	0.28	0.31	0.32			
2 $\frac{3}{4}$	0.47	0.32	0.38	0.42	0.44	0.46		
3	0.64	0.41	0.49	0.55	0.59	0.61	0.63	
3 $\frac{1}{4}$	0.85	0.52	0.62	0.70	0.76	0.80	0.82	0.84
3 $\frac{1}{2}$	1.11	0.64	0.77	0.88	0.96	1.02	1.06	1.08
3 $\frac{3}{4}$	1.42	0.78	0.95	1.08	1.19	1.27	1.32	1.36
4	1.79	0.93	1.14	1.31	1.45	1.55	1.63	1.69
4 $\frac{1}{4}$	2.21	1.10	1.36	1.57	1.74	1.88	1.98	2.06
4 $\frac{1}{2}$	2.71	1.29	1.60	1.86	2.07	2.24	2.37	2.48
4 $\frac{3}{4}$	3.29	1.50	1.87	2.17	2.43	2.64	2.81	2.95
5	3.94	1.73	2.16	2.52	2.83	3.09	3.30	3.47
5 $\frac{1}{4}$	4.69	1.98	2.47	2.90	3.27	3.58	3.83	4.04
5 $\frac{1}{2}$	5.53	2.24	2.82	3.32	3.74	4.11	4.42	4.68
5 $\frac{3}{4}$	6.48	2.53	3.19	3.76	4.26	4.69	5.05	5.36
6	7.53	2.84	3.59	4.25	4.82	5.32	5.75	6.11
6 $\frac{1}{4}$	8.71	3.18	4.02	4.76	5.42	5.99	6.49	6.92
6 $\frac{1}{2}$	10.01	3.53	4.48	5.32	6.06	6.72	7.29	7.79
6 $\frac{3}{4}$	11.44	3.91	4.97	5.91	6.75	7.50	8.15	8.73
7	13.02	4.31	5.49	6.54	7.49	8.33	9.07	9.73
7 $\frac{1}{4}$	14.75	4.74	6.04	7.21	8.27	9.21	10.06	10.80
7 $\frac{1}{2}$	16.63	5.19	6.62	7.92	9.10	10.16	11.10	11.94
7 $\frac{3}{4}$	18.68	5.67	7.24	8.68	9.98	11.15	12.21	13.15
8	20.91	6.17	7.89	9.47	10.91	12.21	13.38	14.44
8 $\frac{1}{4}$	23.33	6.70	8.58	10.31	11.89	13.32	14.62	15.79
8 $\frac{1}{2}$	25.94	7.25	9.30	11.19	12.92	14.49	15.93	17.23
8 $\frac{3}{4}$	28.75	7.83	10.06	12.11	14.00	15.73	17.30	18.74
9	31.77	8.44	10.86	13.09	15.14	17.02	18.75	20.33
9 $\frac{1}{4}$	35.02	9.08	11.69	14.10	16.33	18.38	20.27	22.00
9 $\frac{1}{2}$	38.49	9.75	12.56	15.16	17.58	19.81	21.86	23.75
9 $\frac{3}{4}$	42.21	10.44	13.46	16.27	18.88	21.30	23.53	25.58
10	46.18	11.16	14.41	17.43	20.24	22.85	25.27	27.50

Cast-iron 26 feet long.

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1¼ Inch.	1½ Inch.	1½ Inch.	1¾ Inch.	1¾ Inch.	1¾ Inch.	2 Inch.
Inches.							
2							
2¼							
2½							
2¾							
3							
3¼							
3½	1.10						
3¾	1.39	1.41					
4	1.73	1.76	1.77				
4¼	2.12	2.16	2.18	2.20			
4½	2.56	2.62	2.66	2.68	2.70		
4¾	3.05	3.13	3.19	3.23	3.26	3.27	
5	3.61	3.71	3.79	3.85	3.89	3.91	3.93
5¼	4.22	4.35	4.46	4.54	4.59	4.63	4.66
5½	4.89	5.06	5.19	5.30	5.38	5.43	5.47
5¾	5.62	5.83	6.00	6.14	6.24	6.32	6.38
6	6.42	6.68	6.89	7.06	7.19	7.30	7.38
6¼	7.29	7.59	7.85	8.06	8.23	8.37	8.47
6½	8.22	8.59	8.90	9.15	9.36	9.53	9.67
6¾	9.23	9.65	10.02	10.33	10.59	10.80	10.97
7	10.31	10.80	11.23	11.60	11.91	12.16	12.37
7¼	11.46	12.03	12.53	12.96	13.32	13.63	13.89
7½	12.69	13.34	13.92	14.42	14.84	15.21	15.52
7¾	14.00	14.74	15.40	15.97	16.47	16.90	17.26
8	15.38	16.22	16.97	17.63	18.20	18.70	19.13
8¼	16.85	17.80	18.64	19.38	20.04	20.61	21.11
8½	18.40	19.46	20.40	21.25	21.99	22.65	23.22
8¾	20.04	21.21	22.27	23.22	24.06	24.80	25.46
9	21.76	23.06	24.24	25.29	26.24	27.08	27.83
9¼	23.57	25.01	26.31	27.48	28.54	29.48	30.33
9½	25.47	27.05	28.48	29.79	30.96	32.02	32.96
9¾	27.46	29.19	30.77	32.20	33.50	34.68	35.73
10	29.55	31.43	33.16	34.74	36.17	37.47	38.65

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support,
ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	$1\frac{1}{8}$ Inch.
Inches.								
2	0.14	0.12	0.13					
$2\frac{1}{4}$	0.22	0.17	0.19	0.20				
$2\frac{1}{2}$	0.32	0.23	0.26	0.29	0.30			
$2\frac{3}{4}$	0.44	0.30	0.35	0.39	0.42	0.43		
3	0.60	0.39	0.46	0.51	0.55	0.58	0.59	
$3\frac{1}{4}$	0.80	0.48	0.58	0.66	0.71	0.75	0.77	0.79
$3\frac{1}{2}$	1.04	0.60	0.73	0.82	0.90	0.95	0.99	1.01
$3\frac{3}{4}$	1.33	0.73	0.89	1.02	1.11	1.19	1.24	1.28
4	1.67	0.87	1.07	1.23	1.36	1.46	1.53	1.59
$4\frac{1}{4}$	2.08	1.03	1.28	1.47	1.63	1.76	1.86	1.93
$4\frac{1}{2}$	2.54	1.21	1.50	1.74	1.94	2.10	2.23	2.33
$4\frac{3}{4}$	3.08	1.41	1.75	2.04	2.28	2.48	2.64	2.77
5	3.70	1.62	2.02	2.37	2.66	2.90	3.09	3.25
$5\frac{1}{4}$	4.40	1.85	2.32	2.72	3.06	3.35	3.60	3.79
$5\frac{1}{2}$	5.19	2.10	2.64	3.11	3.51	3.85	4.14	4.39
$5\frac{3}{4}$	6.07	2.37	2.99	3.53	4.00	4.40	4.74	5.03
6	7.06	2.67	3.37	3.98	4.52	4.99	5.39	5.73
$6\frac{1}{4}$	8.17	2.98	3.77	4.47	5.08	5.62	6.09	6.49
$6\frac{1}{2}$	9.38	3.31	4.20	4.99	5.69	6.30	6.84	7.31
$6\frac{3}{4}$	10.73	3.67	4.66	5.54	6.33	7.03	7.65	8.19
7	12.21	4.04	5.14	6.14	7.02	7.81	8.51	9.13
$7\frac{1}{4}$	13.83	4.44	5.66	6.76	7.76	8.64	9.43	10.13
$7\frac{1}{2}$	15.60	4.87	6.21	7.43	8.53	9.52	10.41	11.20
$7\frac{3}{4}$	17.52	5.31	6.79	8.14	9.36	10.46	11.45	12.34
8	19.61	5.78	7.40	8.88	10.23	11.45	12.55	13.54
$8\frac{1}{4}$	21.88	6.28	8.05	9.67	11.15	12.49	13.71	14.81
$8\frac{1}{2}$	24.32	6.80	8.72	10.49	12.11	13.59	14.94	16.16
$8\frac{3}{4}$	26.96	7.35	9.44	11.36	13.13	14.75	16.23	17.57
9	29.80	7.92	10.18	12.27	14.20	15.97	17.59	19.06
$9\frac{1}{4}$	32.84	8.52	10.96	13.22	15.32	17.24	19.01	20.63
$9\frac{1}{2}$	36.10	9.14	11.78	14.22	16.49	18.58	20.50	22.27
$9\frac{3}{4}$	39.59	9.79	12.63	15.26	17.71	19.97	22.06	23.99
10	43.31	10.47	13.51	16.35	18.99	21.43	23.70	25.79

Cast-iron 27 feet long.

if solid, as in the first column, or if hollow, as in the succeed- the respective headings.							
Diameter of Pillar outside.	1 $\frac{1}{4}$ Inch.	1 $\frac{3}{8}$ Inch.	1 $\frac{1}{2}$ Inch.	1 $\frac{5}{8}$ Inch.	1 $\frac{3}{4}$ Inch.	1 $\frac{7}{8}$ Inch.	2 Inch.
Inches.							
2							
2 $\frac{1}{4}$							
2 $\frac{1}{2}$							
2 $\frac{3}{4}$							
3							
3 $\frac{1}{4}$							
3 $\frac{1}{2}$	1.03						
3 $\frac{3}{4}$	1.30	1.32					
4	1.62	1.65	1.66				
4 $\frac{1}{4}$	1.99	2.03	2.05	2.06			
4 $\frac{1}{2}$	2.40	2.45	2.49	2.52	2.53		
4 $\frac{3}{4}$	2.86	2.94	2.99	3.03	3.05	3.07	
5	3.38	3.48	3.55	3.61	3.65	3.67	3.69
5 $\frac{1}{4}$	3.95	4.08	4.18	4.25	4.31	4.35	4.37
5 $\frac{1}{2}$	4.58	4.74	4.87	4.97	5.04	5.10	5.14
5 $\frac{3}{4}$	5.27	5.47	5.63	5.76	5.86	5.93	5.98
6	6.02	6.26	6.46	6.62	6.75	6.85	6.92
6 $\frac{1}{4}$	6.83	7.12	7.36	7.56	7.72	7.85	7.95
6 $\frac{1}{2}$	7.71	8.05	8.34	8.58	8.78	8.94	9.07
6 $\frac{3}{4}$	8.65	9.05	9.40	9.69	9.93	10.13	10.29
7	9.66	10.13	10.53	10.88	11.17	11.41	11.61
7 $\frac{1}{4}$	10.75	11.28	11.75	12.15	12.50	12.79	13.03
7 $\frac{1}{2}$	11.90	12.52	13.05	13.52	13.92	14.27	14.56
7 $\frac{3}{4}$	13.13	13.82	14.44	14.98	15.45	15.85	16.19
8	14.43	15.22	15.92	16.53	17.07	17.54	17.94
8 $\frac{1}{4}$	15.80	16.69	17.48	18.18	18.80	19.33	19.80
8 $\frac{1}{2}$	17.26	18.25	19.14	19.93	20.62	21.24	21.78
8 $\frac{3}{4}$	18.79	19.90	20.89	21.77	22.56	23.26	23.88
9	20.41	21.63	22.73	23.72	24.61	25.40	26.10
9 $\frac{1}{4}$	22.11	23.45	24.67	25.77	26.77	27.65	28.44
9 $\frac{1}{2}$	23.89	25.37	26.71	27.93	29.04	30.03	30.91
9 $\frac{3}{4}$	25.76	27.38	28.86	30.20	31.42	32.52	33.51
10	27.71	29.48	31.10	32.58	33.92	35.14	36.25

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support,
ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside. Inches.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	$1\frac{1}{8}$ Inch.
2	0.13	0.11	0.12					
$2\frac{1}{4}$	0.20	0.16	0.18	0.19				
$2\frac{1}{2}$	0.30	0.21	0.25	0.27	0.29			
$2\frac{3}{4}$	0.42	0.28	0.33	0.37	0.39	0.40		
3	0.57	0.36	0.43	0.48	0.52	0.54	0.56	
$3\frac{1}{4}$	0.75	0.46	0.55	0.62	0.67	0.70	0.73	0.74
$3\frac{1}{2}$	0.98	0.56	0.68	0.78	0.85	0.90	0.93	0.95
$3\frac{3}{4}$	1.25	0.68	0.84	0.95	1.05	1.12	1.17	1.20
4	1.57	0.82	1.01	1.16	1.28	1.37	1.44	1.49
$4\frac{1}{4}$	1.95	0.97	1.20	1.38	1.54	1.65	1.75	1.82
$4\frac{1}{2}$	2.39	1.14	1.41	1.64	1.82	1.97	2.09	2.19
$4\frac{3}{4}$	2.90	1.32	1.64	1.92	2.14	2.33	2.48	2.60
5	3.48	1.52	1.90	2.22	2.50	2.72	2.91	3.06
$5\frac{1}{4}$	4.13	1.74	2.18	2.56	2.88	3.15	3.38	3.57
$5\frac{1}{2}$	4.88	1.98	2.48	2.92	3.30	3.62	3.90	4.12
$5\frac{3}{4}$	5.71	2.23	2.81	3.32	3.76	4.13	4.46	4.73
6	6.64	2.51	3.16	3.74	4.25	4.69	5.07	5.39
$6\frac{1}{4}$	7.68	2.80	3.54	4.20	4.78	5.28	5.72	6.10
$6\frac{1}{2}$	8.82	3.11	3.95	4.69	5.35	5.92	6.43	6.87
$6\frac{3}{4}$	10.09	3.45	4.38	5.21	5.95	6.61	7.19	7.70
7	11.48	3.80	4.84	5.77	6.60	7.34	8.00	8.58
$7\frac{1}{4}$	13.00	4.18	5.32	6.36	7.29	8.12	8.87	9.52
$7\frac{1}{2}$	14.66	4.57	5.84	6.99	8.02	8.95	9.79	10.53
$7\frac{3}{4}$	16.47	4.99	6.38	7.65	8.80	9.83	10.76	11.60
8	18.44	5.44	6.96	8.35	9.62	10.76	11.80	12.73
$8\frac{1}{4}$	20.57	5.90	7.57	9.09	10.48	11.74	12.89	13.93
$8\frac{1}{2}$	22.87	6.39	8.20	9.86	11.39	12.78	14.04	15.19
$8\frac{3}{4}$	25.34	6.91	8.87	10.68	12.34	13.87	15.26	16.52
9	28.01	7.44	9.57	11.54	13.35	15.01	16.53	17.92
$9\frac{1}{4}$	30.87	8.00	10.30	12.43	14.40	16.21	17.87	19.39
$9\frac{1}{2}$	33.94	8.59	11.07	13.37	15.50	17.46	19.27	20.94
$9\frac{3}{4}$	37.21	9.20	11.87	14.35	16.65	18.78	20.74	22.55
10	40.71	9.84	12.70	15.37	17.85	20.15	22.27	24.24

Cast-iron 28 feet long.

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1 $\frac{1}{4}$ Inch.	1 $\frac{3}{8}$ Inch.	1 $\frac{1}{2}$ Inch.	1 $\frac{5}{8}$ Inch.	1 $\frac{3}{4}$ Inch.	1 $\frac{7}{8}$ Inch.	2 Inch.
Inches.							
2							
2 $\frac{1}{4}$							
2 $\frac{1}{2}$							
2 $\frac{3}{4}$							
3							
3 $\frac{1}{4}$							
3 $\frac{1}{2}$	0.97						
3 $\frac{3}{4}$	1.23	1.24					
4	1.53	1.55	1.56				
4 $\frac{1}{4}$	1.87	1.90	1.93	1.94			
4 $\frac{1}{2}$	2.26	2.31	2.34	2.37	2.38		
4 $\frac{3}{4}$	2.69	2.76	2.81	2.85	2.87	2.89	
5	3.18	3.27	3.34	3.39	3.43	3.45	3.46
5 $\frac{1}{4}$	3.72	3.84	3.93	4.00	4.05	4.08	4.11
5 $\frac{1}{2}$	4.31	4.46	4.58	4.67	4.74	4.79	4.83
5 $\frac{3}{4}$	4.96	5.14	5.29	5.41	5.50	5.57	5.62
6	5.66	5.89	6.07	6.22	6.34	6.44	6.51
6 $\frac{1}{4}$	6.42	6.70	6.92	7.11	7.26	7.38	7.47
6 $\frac{1}{2}$	7.25	7.57	7.84	8.07	8.25	8.41	8.52
6 $\frac{3}{4}$	8.13	8.51	8.83	9.11	9.33	9.52	9.67
7	9.09	9.52	9.90	10.22	10.50	10.72	10.91
7 $\frac{1}{4}$	10.10	10.61	11.05	11.43	11.75	12.02	12.25
7 $\frac{1}{2}$	11.19	11.76	12.27	12.71	13.09	13.41	13.68
7 $\frac{3}{4}$	12.34	13.00	13.57	14.08	14.52	14.90	15.22
8	13.56	14.30	14.96	15.54	16.05	16.49	16.86
8 $\frac{1}{4}$	14.86	15.69	16.43	17.09	17.67	18.17	18.61
8 $\frac{1}{2}$	16.22	17.16	17.99	18.73	19.39	19.97	20.47
8 $\frac{3}{4}$	17.67	18.70	19.63	20.47	21.21	21.87	22.45
9	19.19	20.33	21.37	22.30	23.13	23.88	24.53
9 $\frac{1}{4}$	20.78	22.05	23.19	24.23	25.16	25.99	26.74
9 $\frac{1}{2}$	22.46	23.85	25.11	26.26	27.30	28.23	29.06
9 $\frac{3}{4}$	24.21	25.74	27.13	28.39	29.54	30.57	31.50
10	26.05	27.71	29.24	30.63	31.89	33.04	34.07

Cylindrical Pillars of

Safe weights, in tons of 2,000 pounds, which they can support,
ing columns, in which the thickness of the iron is given in

Diameter of Pillar outside. Inches.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	$1\frac{1}{8}$ Inch.
2	0.13	0.10	0.12					
$2\frac{1}{4}$	0.19	0.15	0.17	0.18				
$2\frac{1}{2}$	0.28	0.20	0.23	0.26	0.27			
$2\frac{3}{4}$	0.39	0.26	0.31	0.35	0.37	0.38		
3	0.53	0.34	0.41	0.45	0.49	0.51	0.52	
$3\frac{1}{4}$	0.71	0.43	0.52	0.58	0.63	0.66	0.69	0.70
$3\frac{1}{2}$	0.92	0.53	0.64	0.73	0.80	0.84	0.88	0.90
$3\frac{3}{4}$	1.18	0.64	0.79	0.90	0.99	1.05	1.10	1.13
4	1.48	0.77	0.95	1.09	1.20	1.29	1.36	1.40
$4\frac{1}{4}$	1.84	0.92	1.13	1.30	1.45	1.56	1.65	1.71
$4\frac{1}{2}$	2.25	1.07	1.33	1.54	1.72	1.86	1.97	2.06
$4\frac{3}{4}$	2.73	1.25	1.55	1.81	2.02	2.20	2.34	2.45
5	3.27	1.44	1.79	2.10	2.35	2.56	2.74	2.88
$5\frac{1}{4}$	3.89	1.64	2.05	2.41	2.71	2.97	3.18	3.36
$5\frac{1}{2}$	4.59	1.86	2.34	2.75	3.11	3.41	3.67	3.88
$5\frac{3}{4}$	5.38	2.10	2.65	3.12	3.54	3.89	4.20	4.45
6	6.26	2.36	2.98	3.53	4.00	4.42	4.77	5.08
$6\frac{1}{4}$	7.23	2.64	3.34	3.96	4.50	4.98	5.39	5.75
$6\frac{1}{2}$	8.31	2.93	3.72	4.42	5.04	5.58	6.06	6.47
$6\frac{3}{4}$	9.50	3.25	4.12	4.91	5.61	6.23	6.77	7.25
7	10.81	3.58	4.56	5.43	6.22	6.92	7.54	8.08
$7\frac{1}{4}$	12.25	3.94	5.02	5.99	6.87	7.65	8.35	8.97
$7\frac{1}{2}$	13.81	4.31	5.50	6.58	7.56	8.43	9.22	9.92
$7\frac{3}{4}$	15.52	4.71	6.02	7.21	8.29	9.26	10.14	10.93
8	17.37	5.12	6.56	7.87	9.06	10.14	11.11	11.99
$8\frac{1}{4}$	19.37	5.56	7.13	8.56	9.87	11.06	12.14	13.12
$8\frac{1}{2}$	21.54	6.02	7.73	9.29	10.73	12.04	13.23	14.31
$8\frac{3}{4}$	23.88	6.51	8.36	10.06	11.63	13.06	14.37	15.56
9	26.39	7.01	9.02	10.87	12.57	14.14	15.57	16.88
$9\frac{1}{4}$	29.08	7.54	9.71	11.71	13.56	15.27	16.84	18.27
$9\frac{1}{2}$	31.97	8.09	10.43	12.59	14.60	16.45	18.16	19.72
$9\frac{3}{4}$	35.06	8.67	11.18	13.52	15.68	17.69	19.54	21.25
10	38.36	9.27	11.97	14.48	16.81	18.98	20.99	22.84

Cast iron 29 feet long.

if solid, as in the first column, or if hollow, as in the succeed-
the respective headings.

Diameter of Pillar outside.	1 $\frac{1}{4}$ Inch.	1 $\frac{3}{8}$ Inch.	1 $\frac{1}{2}$ Inch.	1 $\frac{5}{8}$ Inch.	1 $\frac{3}{4}$ Inch.	1 $\frac{7}{8}$ Inch.	2 Inch.
Inches.							
2							
2 $\frac{1}{4}$							
2 $\frac{1}{2}$							
2 $\frac{3}{4}$							
3							
3 $\frac{1}{4}$							
3 $\frac{1}{2}$	0.91						
3 $\frac{3}{4}$	1.15	1.17					
4	1.44	1.46	1.47				
4 $\frac{1}{4}$	1.76	1.79	1.81	1.83			
4 $\frac{1}{2}$	2.13	2.17	2.21	2.23	2.24		
4 $\frac{3}{4}$	2.54	2.60	2.65	2.68	2.71	2.72	
5	2.99	3.08	3.15	3.20	3.23	3.25	3.26
5 $\frac{1}{4}$	3.50	3.61	3.70	3.77	3.81	3.85	3.87
5 $\frac{1}{2}$	4.06	4.20	4.31	4.40	4.47	4.51	4.55
5 $\frac{3}{4}$	4.67	4.84	4.99	5.10	5.19	5.25	5.30
6	5.33	5.55	5.72	5.86	5.98	6.06	6.13
6 $\frac{1}{4}$	6.05	6.31	6.52	6.70	6.84	6.95	7.04
6 $\frac{1}{2}$	6.83	7.13	7.39	7.60	7.78	7.92	8.03
6 $\frac{3}{4}$	7.66	8.02	8.32	8.58	8.79	8.97	9.11
7	8.56	8.97	9.33	9.63	9.89	10.10	10.28
7 $\frac{1}{4}$	9.52	9.99	10.41	10.76	11.07	11.32	11.54
7 $\frac{1}{2}$	10.54	11.08	11.56	11.97	12.33	12.63	12.89
7 $\frac{3}{4}$	11.62	12.24	12.79	13.27	13.68	14.04	14.34
8	12.78	13.48	14.09	14.64	15.12	15.53	15.89
8 $\frac{1}{4}$	14.00	14.78	15.48	16.10	16.64	17.12	17.54
8 $\frac{1}{2}$	15.28	16.16	16.95	17.65	18.27	18.81	19.29
8 $\frac{3}{4}$	16.64	17.62	18.50	19.28	19.98	20.60	21.15
9	18.08	19.16	20.13	21.01	21.79	22.49	23.11
9 $\frac{1}{4}$	19.58	20.77	21.85	22.83	23.70	24.49	25.19
9 $\frac{1}{2}$	21.16	22.47	23.66	24.74	25.71	26.59	27.38
9 $\frac{3}{4}$	22.81	24.25	25.56	26.75	27.83	28.80	29.68
10	24.54	26.11	27.54	28.85	30.04	31.12	32.10

Cylindrical Pillars of

Safe weight, in tons of 2,000 pounds, which they can support, ing columns, in which the thickness of the iron is given in								
Diameter of Pillar outside.	Solid.	$\frac{3}{8}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{5}{8}$ Inch.	$\frac{3}{4}$ Inch.	$\frac{7}{8}$ Inch.	1 Inch.	1 $\frac{1}{2}$ Inch.
Inches.								
2	0.12	0.10	0.11					
2 $\frac{1}{4}$	0.18	0.14	0.16	0.17				
2 $\frac{1}{2}$	0.26	0.19	0.22	0.24	0.25			
2 $\frac{3}{4}$	0.37	0.25	0.30	0.33	0.35	0.36		
3	0.50	0.32	0.38	0.43	0.46	0.48	0.49	
3 $\frac{1}{4}$	0.67	0.41	0.49	0.55	0.60	0.63	0.65	0.66
3 $\frac{1}{2}$	0.87	0.50	0.61	0.69	0.75	0.80	0.83	0.85
3 $\frac{3}{4}$	1.11	0.61	0.74	0.85	0.93	0.99	1.04	1.07
4	1.40	0.73	0.90	1.03	1.14	1.22	1.28	1.33
4 $\frac{1}{4}$	1.74	0.86	1.07	1.23	1.37	1.47	1.55	1.62
4 $\frac{1}{2}$	2.13	1.01	1.26	1.46	1.62	1.76	1.86	1.94
4 $\frac{3}{4}$	2.58	1.18	1.46	1.71	1.91	2.07	2.21	2.31
5	3.09	1.35	1.69	1.98	2.22	2.42	2.59	2.72
5 $\frac{1}{4}$	3.68	1.55	1.94	2.28	2.56	2.80	3.01	3.17
5 $\frac{1}{2}$	4.34	1.76	2.21	2.60	2.94	3.22	3.46	3.67
5 $\frac{3}{4}$	5.08	1.99	2.50	2.95	3.34	3.68	3.96	4.21
6	5.91	2.23	2.81	3.33	3.78	4.17	4.50	4.79
6 $\frac{1}{4}$	6.83	2.49	3.15	3.73	4.25	4.70	5.09	5.43
6 $\frac{1}{2}$	7.85	2.77	3.51	4.17	4.75	5.27	5.72	6.11
6 $\frac{3}{4}$	8.97	3.07	3.89	4.63	5.29	5.88	6.39	6.84
7	10.21	3.38	4.30	5.13	5.87	6.53	7.12	7.63
7 $\frac{1}{4}$	11.56	3.71	4.73	5.66	6.48	7.22	7.88	8.47
7 $\frac{1}{2}$	13.04	4.07	5.19	6.21	7.13	7.96	8.70	9.36
7 $\frac{3}{4}$	14.65	4.44	5.68	6.80	7.82	8.74	9.57	10.31
8	16.40	4.84	6.19	7.43	8.55	9.57	10.49	11.32
8 $\frac{1}{4}$	18.29	5.25	6.73	8.08	9.32	10.44	11.46	12.38
8 $\frac{1}{2}$	20.33	5.69	7.29	8.77	10.13	11.36	12.49	13.51
8 $\frac{3}{4}$	22.54	6.14	7.89	9.50	10.98	12.33	13.57	14.69
9	24.91	6.62	8.51	10.26	11.87	13.35	14.70	15.94
9 $\frac{1}{4}$	27.45	7.12	9.16	11.06	12.80	14.41	15.89	17.25
9 $\frac{1}{2}$	30.18	7.64	9.84	11.89	13.78	15.53	17.14	18.62
9 $\frac{3}{4}$	33.10	8.19	10.56	12.76	14.80	16.70	18.45	20.05
10	36.21	8.75	11.30	13.67	15.87	17.92	19.81	21.56

Cast-iron 30 feet long.

if solid, as in the first column, or if hollow, as in the succeed- the respective headings.							
Diameter of Pillar outside.	1 $\frac{1}{4}$ Inch.	1 $\frac{3}{8}$ Inch.	1 $\frac{1}{2}$ Inch.	1 $\frac{5}{8}$ Inch.	1 $\frac{3}{4}$ Inch.	1 $\frac{7}{8}$ Inch.	2 Inch.
Inches.							
2							
2 $\frac{1}{4}$							
2 $\frac{1}{2}$							
2 $\frac{3}{4}$							
3							
3 $\frac{1}{4}$							
3 $\frac{1}{2}$	0.86						
3 $\frac{3}{4}$	1.09	1.10					
4	1.36	1.38	1.39				
4 $\frac{1}{4}$	1.66	1.69	1.71	1.73			
4 $\frac{1}{2}$	2.01	2.05	2.08	2.10	2.12		
4 $\frac{3}{4}$	2.39	2.46	2.50	2.53	2.55	2.57	
5	2.83	2.91	2.97	3.02	3.05	3.07	3.08
5 $\frac{1}{4}$	3.31	3.41	3.49	3.56	3.60	3.63	3.65
5 $\frac{1}{2}$	3.83	3.97	4.07	4.15	4.22	4.26	4.29
5 $\frac{3}{4}$	4.41	4.57	4.71	4.81	4.89	4.96	5.00
6	5.03	5.23	5.40	5.53	5.64	5.72	5.78
6 $\frac{1}{4}$	5.71	5.95	6.16	6.32	6.46	6.56	6.64
6 $\frac{1}{2}$	6.45	6.73	6.97	7.18	7.34	7.48	7.58
6 $\frac{3}{4}$	7.23	7.57	7.86	8.10	8.30	8.47	8.60
7	8.08	8.47	8.81	9.09	9.34	9.54	9.70
7 $\frac{1}{4}$	8.98	9.43	9.82	10.16	10.45	10.69	10.89
7 $\frac{1}{2}$	9.95	10.46	10.91	11.30	11.64	11.93	12.17
7 $\frac{3}{4}$	10.97	11.56	12.07	12.52	12.91	13.25	13.54
8	12.06	12.72	13.31	13.82	14.27	14.66	15.00
8 $\frac{1}{4}$	13.21	13.95	14.61	15.20	15.71	16.16	16.55
8 $\frac{1}{2}$	14.43	15.26	16.00	16.66	17.24	17.76	18.21
8 $\frac{3}{4}$	15.71	16.63	17.46	18.20	18.86	19.45	19.96
9	17.06	18.08	19.00	19.83	20.57	21.23	21.82
9 $\frac{1}{4}$	18.48	19.61	20.63	21.55	22.38	23.12	23.78
9 $\frac{1}{2}$	19.97	21.21	22.33	23.35	24.27	25.10	25.84
9 $\frac{3}{4}$	21.53	22.89	24.12	25.25	26.27	27.19	28.02
10	23.17	24.65	26.00	27.24	28.36	29.38	30.30

Five hundred and forty-seventh Meeting.

February 27, 1865. — SPECIAL MEETING.

The PRESIDENT in the chair.

Addresses were made by the President, Mr. Safford, and Professor Parsons on the scientific services and character of the late Professor Bond.

Mr. Whitney read a paper on the development of the mineral productions of California and the adjacent Territories.

Five hundred and forty-eighth Meeting.

March 14, 1865. — ADJOURNED STATUTE MEETING.

The PRESIDENT in the chair.

The Corresponding Secretary read letters relative to exchanges; also a letter from Leopold von Ranke of Berlin, in acknowledgment of his election into the Academy.

The following paper was presented:—

On a New Process for the Determination of Sulphur in Organic Compounds, by Combustion with Oxygen Gas and Peroxide of Lead. By C. M. WARREN.

IN my former communication "On a Process of Organic Elementary Analysis by Combustion in a Stream of Oxygen Gas,"* I treated exclusively of the determination of carbon and hydrogen in volatile liquid hydrocarbons,—my experiments up to that time having been confined to the analysis of substances of this class. It was my intention, however, to have applied the process before this to other classes of bodies, and especially to have tested its applicability, with suitable modifications, for the analysis of organic substances containing other elements.

Other work with which I was then occupied, and to which this process was only incidental, as already stated in the paper referred to, has prevented me from extending the research beyond the requirements of my other investigations.

* Proceedings of the American Academy, 1864, p. 251.

Having recently had occasion to determine sulphur in some volatile liquid compounds, for which neither of the processes now in use seemed satisfactorily adapted, I was naturally led to make an effort to utilize my safety-tube and the stream of oxygen in this species of analysis also. But the fact that sulphur is usually, at least, but partially converted into sulphuric acid by combustion in oxygen gas, seemed at first to present a difficulty not to be easily overcome. It soon occurred to me, however, that the well-known reaction between sulphurous acid and peroxide of lead, by which the former is completely converted into sulphuric acid, might probably serve to remove this objection. Furthermore, that by placing the peroxide of lead within the combustion-tube in the manner which I shall presently describe, and by maintaining the peroxide of lead at a temperature sufficient to prevent condensation of water within the combustion-tube, the carbon, hydrogen, and sulphur might all be determined from the same portion of substance. This result has been accomplished.*

Referring to my former paper above mentioned for details regarding the construction and use of the apparatus employed, I need here describe only such modifications as have been found expedient to adapt the process to this special purpose.

The combustion-tube being packed with pure asbestos between the points *a* and *b*, Fig. I., and the space — about two inches in length — between *b* and *c* left vacant, a plug of pure asbestos is placed at *c*, and

Fig. I.



* Carius (*Annalen der Chemie und Pharmacie*, 1860, CXVI. 28) has observed that when substances rich in sulphur are burnt with oxide of copper — a tube containing peroxide of lead being placed between the chloride of calcium tube and the potash bulbs in the usual manner — the determination of carbon is too high. And on the other hand he found that, with substances rich in carbon the determination of the carbon was too low. In the latter case the peroxide of lead was supposed to absorb and retain carbonic acid; and in the former, sulphurous acid was found to pass unabsorbed through the peroxide of lead.

The incomplete absorption of the sulphurous acid may be reasonably accounted for on the supposition that a channel was formed, by handling or jarring, along the top of the peroxide of lead, which indeed would be very likely to occur in using, by itself, so heavy a powder. Through such a channel sulphurous acid might pass, in so small proportion, without coming in contact with the peroxide of lead. It

the space between *c* and *d*, about three or four inches in length, then filled with a mixture of pure asbestos and peroxide of lead, and finally a plug of asbestos is placed at *d*. As the sulphuric acid formed is to be absorbed by, and finally determined from, the peroxide of lead, — in order to obviate the necessity of treating the whole of the asbestos in the tube to obtain the sulphuric acid, which would be troublesome, and at the same time preserve the asbestos packing in the posterior part of the tube in a fit condition for future use, — it is important that the asbestos plug at *c* should be packed closely enough to prevent any particles of the peroxide of lead from passing back of this plug.

As already stated, the object of mixing asbestos with the peroxide of lead is to prevent the formation of a channel along the top. In this manner but a short column of the mixture of asbestos and peroxide of lead will suffice to secure complete conversion of the sulphurous acid. The combustion is conducted precisely as for the determination of carbon and hydrogen alone, except that the portion of the tube which contains the peroxide of lead is maintained at a gentle heat, sufficient to prevent condensation of water in that part of the tube and at the cork, but avoiding a temperature which would decompose the peroxide of lead. As usual, the water formed is absorbed in a chloride of calcium tube, and the carbonic acid in Liebig's potash bulbs with a mulder tube attached.

After the close of the combustion, when the tube shall have sufficiently cooled it is carefully removed from the furnace, the mixture of peroxide

will be seen that the liability to the formation of a channel is obviated in my process by mixing the peroxide of lead with a large proportion of asbestos. The asbestos serves also to increase the porosity of the mass, and in this manner also to lessen the chances of escape of sulphurous acid without coming in contact with the peroxide. I may here add that, in making the combustion with oxygen in presence of asbestos, the quantity of sulphurous acid which reaches the peroxide of lead is by no means very large. In a preliminary experiment in which carbonate of soda was employed instead of peroxide of lead, (the substance burnt being bisulphide of carbon,) the carbonate of soda was found to contain within about 9 per cent of the equivalent quantity of sulphur; and a portion of the deficiency it is not unlikely may have been taken up by the impure asbestos that was employed in this instance.

Concerning the other source of error in the determination of carbon which Carius mentions, it will suffice to remark that, in my process, the peroxide of lead is kept at so high a temperature that the absorption of carbonic acid appears to be prevented.

of lead and asbestos cautiously drawn out into a beaker glass, by means of a bent iron wire, and the tube then inverted within another tube, *ee*, closed at one end, as shown in Fig. II. The mixture of peroxide of lead and asbestos contained in the beaker glass is now treated with a strong solution of bi-carbonate of soda, and left to stand for about twenty-four hours, with frequent shaking.*

Solution of bi-carbonate of soda is also poured into the tube *ee* until the level of the liquid shall have reached a point, *f*, on the combustion-tube, a little above that which was occupied by the plug *c*, and this is also left to stand as the other. After the lapse of sufficient time for the reaction to be completed, the solution is filtered from the asbestos mixture, including also the solution in the tube *ee*, and not omitting to carefully rinse out the anterior portion of the combustion-tube. The asbestos mixture upon the filter is then thoroughly washed, the filtrate concentrated by evaporation, and the sulphuric acid precipitated with chloride of barium.

The following results of analyses of bi-sulphide of carbon indicate the degree of accuracy afforded by this process.

The preparation employed was commercial bi-sulphide of carbon, which was first subjected to re-distillation.

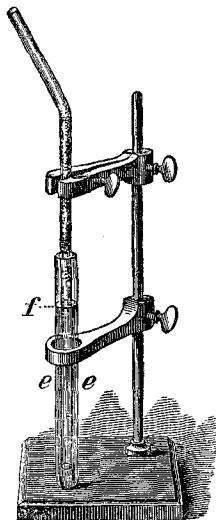
Analysis 1. 0.1414 gramme of bi-sulphide of carbon gave 0.0806 of carbonic acid, and 0.8592 of sulphate of baryta.

		Calculated.		Found.
Carbon,	C	6	15.79	15.61
Sulphur,	S ₂	32	84.21	83.70
			100.00	99.31

Analysis 2. 0.274 gramme of the same substance gave 0.158 of carbonic acid, and 1.6768 of sulphate of baryta.

		Calculated.		Found.
Carbon,	C	6	15.79	15.73
Sulphur,	S ₂	32	84.21	84.05
			100.00	99.78

Fig. II.



* H. Rose, *Chimie Analytique*, new French edition, p. 662.

Analysis 3. In this analysis, in which I was prevented from determining the carbon, 0.1537 of bi-sulphide of carbon gave 0.9461 of sulphate of baryta, corresponding to 84.5 per cent of sulphur.

The mixture of asbestos and peroxide of lead employed was of that which had already been used in the preceding analyses, and may possibly have contained a trace of undecomposed sulphate of lead, as the per cent of sulphur found in this case is 0.3 per cent above, while in the preceding analyses it was a fraction below the theoretical quantity. Trusting, however, that the results already obtained will be deemed sufficient to show the method to be a good one, I have not thought it advisable at this time to further repeat the analysis of this substance. I may here state that I have already applied the process in the analysis of bodies containing hydrogen, and have obtained satisfactory results which will soon be published.

The important advantage thus gained of being able to determine the different elements from the same portion of substance, considering also the simplicity of the process, can hardly fail, I think, to secure for this the preference over the older methods.

Five hundred and forty-ninth Meeting.

March 28, 1865. — SPECIAL MEETING.

The PRESIDENT in the chair.

Professor Gibbs presented the following paper.

Observations on Crystals and Precipitates in Blowpipe Beads.

By GEORGE H. EMERSON.

Believing that the subject of this article is so far novel, at least, as not to have been brought into general notice through the press, I have thought it of sufficient interest to merit publication.

While studying, a few months since, the blowpipe behavior of the alkaline earths, I noticed that the opacity produced by "flaming," or exposing to an intermittent heat, a borax bead sufficiently saturated with one of the earths, was often only partial, — a variable portion of the bead becoming opaque white, while the remainder was perfectly transparent. The extent of the opacity seemed dependent on the duration of the heat. Moreover, when nearly the whole surface was obscured,

the interior was transparent ; for, upon carefully removing the external part of the bead, a clear, vitreous nucleus was disclosed ; but beads exposed to longer heat, when broken showed no trace of this vitreous interior.

But just beginning the study of Chemistry, I was wholly unacquainted with the phenomena of the devitrification of glass, and did not feel well assured, therefore, that crystallization was the cause of this opacity, though it occurred to me at the time that such was probably the case. But if the change produced by flaming was a result of crystallization, then a crystalline structure ought under some circumstances to be discernible ; and the density of the crystallized portion could be no obstacle, as I had already ascertained *that* to be variable at the pleasure of the operator, my experiments yielding results of every degree, from a translucent film to complete opacity. Although density of aggregation did not seem to stand in the way, minuteness of crystalline form might be an impediment to investigation. A borax bead charged with lime exhibited a thin, filmy band stretching across the otherwise transparent surface, when slightly heated with a fine-pointed flame ; but in this I could find no crystals with a hand lens magnifying fourteen diameters. Magnesia, however, when similarly treated, gave a very different result. The bead became studded with beautiful, needle-like crystals, arranged in tufts, or fascicular bunches, and visible even to the naked eye. Several trials with the same base confirmed the fact of crystallization, and showed a surprising uniformity of crystalline form. But was this form, seemingly constant, a character whereby to recognize the earth, or would other members of the group likewise exhibit it, if properly dealt with ? for the experiments with magnesia had taught me that crystals were not always obtained by flaming, an amorphous cloud being sometimes the only result. I reverted to lime ; but with no success. I could get no crystals. Next, I tried baryta. The first trial of slight flaming yielded crystals, of which the hexagonal and rectangular outline could be easily seen without a glass. Sometimes a third shape was visible, looking something like an hour-glass ; but these forms seemed to be constant, and there was nothing in the beads in the least resembling the magnesia crystals. Strontia, similarly treated, yielded transparent crystals of a plumose character.

Three members of the group, then, had yielded crystals with borax ; and crystals possessing quite well-marked distinctive characters. Lime

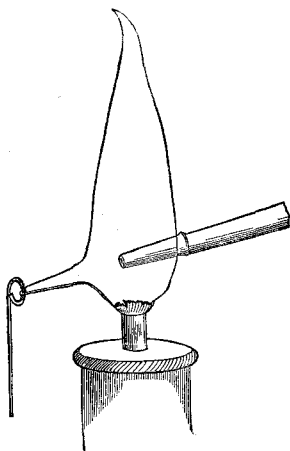
did not crystallize, its opacity, as seen when magnified two hundred diameters, being due to a dense aggregation of exceedingly minute bubbles. Upon treatment with microcosmic salt, lime and magnesia gave, with very slight flaming, nebulous films; that of the former being resolvable into a multitude of spicular crystals, when magnified four hundred times; and the latter into rectangular crystalline forms, in most cases, very nearly square. With the same flux, baryta gave hexagonal crystals, discernible by the naked eye; and which, when not rendered too opaque by prolonged flaming, viewed under the microscope, resembled the common stellate form of snow crystals. Strontia produced equally conspicuous crystals, but of a rectangular form, the length being twice or three times the breadth.

Several experiments with each of the bases just named, in both fluxes, showing no variation in crystalline form from those I had already observed, although in every instance I submitted the result of my trials to microscopic examination, rarely using a less magnifying power than eighty diameters, I passed on to such of the other earths and metallic oxides as were within my reach, of which a list will be found upon page 481.

Before describing in detail the phenomena produced by flaming with these several substances, a few words in reference to the methods pursued may not be unacceptable; premising, however, that these statements, together with all included in these pages, are not predicated upon sufficiently numerous experiments to be regarded as authoritative; and that they are offered rather as suggestions to persons better fitted, and with more ample leisure and opportunity than the author, to follow out the subject exhaustively.

The loop of platinum wire should be about one eighth of an inch in diameter, and quite circular, in order to give as uniform convexity to the surface of the bead as possible. Two turns of the wire are better than one where microcosmic salt is used, on account of the greater fluidity of this flux than borax. The bead should not be much over one twentieth of an inch thick at least, where examination by a high magnifying power is desirable. Crystallization is best produced by thrusting the tip of the blowpipe well into the flame of the lamp, until a fine-pointed jet of flame, less than an inch in length, is obtained; then expose a small portion of the bead, close to the edge, (see diagram,) for an instant to its action, until the part so exposed,

and the wire immediately adjacent, become of a dull red heat, when the bead should be at once withdrawn, and examined with the lens. It may be necessary to repeat this operation several times before crystals are obtained; but the bead should always be cool when heat is applied. Often an amorphous cloud will be the only result, even of repeated trials, although the substance employed is quite easily crystallizable; and this is especially apt to be the case when the bead is too highly charged, or when heated too long, the suspended matter being then so rapidly precipitated as to prevent crystallization. The bead should in such cases be subjected to the action of a powerful flame till perfect transparency is obtained, and, if the first mentioned be the difficulty, a little more of the flux added before again flaming.



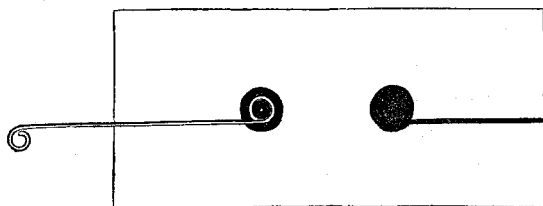
It seems to make little difference with the earths whether the glass containing them be prepared in the oxidating or reducing flame, previous to flaming, though they are most readily dissolved at the point of greatest heat; but the oxides of the non-volatile metals give the best results when the bead is charged in the oxidating, and, after cooling, subjected to the action of a fine-pointed reducing flame. One advantage of using this small fine-pointed flame is, that only a portion of the bead is subjected to the reducing influence; and as the heat is maintained but an instant, the portion of the glass fused is not only circumscribed, but superficial, so that the reaction takes place where it can easily be observed. Moreover, a devitrifying action goes on, at the same time, in the unfused but reheated portion of the bead.* I shall use the term "intermittent flame" to distinguish the ordinary process of flaming from that just described.

The amount of the substance used varies, of course, with the subject of the experiment, although the formation of striæ in the glass,

* As the method of treating beads just described in the text promises to be of value, in certain of its applications, in the arts, as well as of scientific interest, the author intends to secure such applications by patent, after having made some additional experiments.

which are easily seen with the lens, when the bead is not so highly colored as to render them invisible, is in general an indication that the proper point of saturation has been reached.

In examinations with a compound microscope, I have found cork slides, two and one fourth inches long, one inch broad, and one sixth of an inch thick, very convenient. Two perforations are made through the cork, somewhat larger than the beads, which are placed in the centre, and easily retained in position by sinking the wire used for a handle into slits in the cork prepared to receive them. (See diagram.)



This adjustment holds the bead steadily, and, combined with the flexibility of the wire, permits any part of the convex surface to be brought into field, which is very important, as the crystals are very frequently formed only close to the margin.

In photographing the crystallizations, the beads being transparent, and transmitted light employed, the solar rays were reflected from the surface of a *concave* mirror, their power being diminished by the interposition of a piece of ground glass between the mirror and the bead; the curved surface of the bead rendering the illumination by the plane mirror very unsatisfactory.

In regard to the ensuing descriptions of the crystalline reactions of the substances dealt with, although the phenomena differ very perceptibly to the eye of the microscopic observer, yet I have found it exceedingly difficult to convey verbally any exact conception of their differences; and have, therefore, contented myself with roughly sketching the most prominent features, feeling assured that a few easily made experiments will, to persons interested, be in every case far more satisfactory than any written description. On the next page will be found a list of the substances experimented upon.

I cannot conclude these introductory remarks without expressing my obligations to Professor Josiah P. Cooke, who has kindly furnished me with many of the rarer substances experimented with, and to my

friend, Mr. A. E. Verrill, assistant in the Museum of Comparative Zoölogy, to whom I am indebted for the photographs from which the plate was taken, and who, in the midst of pressing occupations, has accomplished for me what professional photographers would not undertake.

LIST OF SUBSTANCES EXPERIMENTED UPON.

Baryta, ...	(Ba O)	Tin, Binoxide of, ...	(Sn O ₂)
Strontia, ...	(Sr O)	Silver, Oxide of, ...	(Ag O)
Lime, ...	(Ca O)	Copper, " "	(Cu O)
Magnesia, ...	(Mg O)	Nickel, " "	(Ni O)
Alumina, ...	(Al ₂ O ₃)	Cobalt, " "	(Co O)
Glucina, ...	(Gl ₂ O ₃)	Manganese, Red Oxide of, .	(Mn ₂ O ₃)
Zirconia, ...	(Zr ₂ O ₃)	Iron, Sesquioxide of, . .	(Fe ₂ O ₃)
Zinc, Oxide of, ...	(Zn O)	Uranium, Sesquioxide of, .	(U ₂ O ₃)
Cadmium, Oxide of, . .	(Cd O)	Chromium, Sesquioxide of, .	(Cr ₂ O ₃)
Lead, " "	(Pb O)	Tungstic Acid, ...	(W O ₃)
Bismuth, Teroxide of, .	(Bi O ₃)	Titanic Acid	(Ti O ₂)
Antimony, " " . . .	(Sb O ₃)	Molybdic Acid, ...	(Mo O ₃)
Arsenic (Arsenious Acid) .	(As O ₃)		

Supplement.

Niobic Acid		(Nb ₂ O ₃)	} Tellurium Cerium, Protoxide of, ... (Ce O)
Selenium			

Baryta.—Baryta is dissolved in borax in large quantities before a precipitate is obtained.* When carefully flamed, opaque, milk-white crystals of a hexagonal, and also of an hourglass shape, are formed (see Plate, Figs. 1 and 2), often distinctly visible even to the naked eye. There are likewise, sometimes, aggregations of rectangular crystals. In what corresponds to the terminal, or basal planes of the hourglass-shaped crystal, a hexagonal outline may be observed in the one delineated in the plate (see Fig. 2); but, rarely having obtained so large and perfect crystals of this form as the one photographed, I am unable to say how constant this feature may be.

With microcosmic salt, slight flaming produces beautiful hexagonal, stellate crystals, not opaque, at least in their inception, and exhibiting a structure resembling some of the commonly depicted forms of snow-flake crystals. Accompanying these I have noticed a rectangular

* As a matter of convenience, I use the term "precipitate" to designate the crystalline or other aggregation, produced by the flaming process within or upon the surface of the bead.

crystal. Further flaming renders these crystals opaque white. They are sometimes produced on cooling merely, without submitting the bead to the flaming process.

Strontia. — Strontia, with borax, yields plumose crystallizations, more or less translucent, according to the state of saturation of the glass, and the amount of flaming; and which are made up of slender, bladed crystals, sometimes arranged around a common centre in nearly circular disks.

With microcosmic salt, slight flaming gives to the surface of the bead a peculiar speckled aspect, due to the formation of oblong, rectangular crystals, varying in size, being often large enough to be made out without using a lens (see Plate, Fig. 3); but never possessing such well-defined angles as the crystallizations of baryta. (See Plate, Fig. 3.) This is a better reaction than that with borax.

Mixed with an equal quantity of baryta, in the same flux, a precipitate is instantaneously produced by flaming, made up of microscopic spiculæ, sometimes asteriated. The most superficial observation would not, however, confound this reaction with that obtainable from the earths separately.

Lime. — Lime, with borax, yields on slight flaming a thin, filmy precipitate, often in the form of a band stretching across the surface of the bead; but in which I have never been able to detect any crystals, the element of opacity being a dense aggregation of colorless, microscopic globules, or bubbles.

Mixed with an equal quantity of magnesia, I have been unable to obtain any different reaction from that just described.

With microcosmic salt, delicate flaming produces a slight precipitate, which, when highly magnified, is seen to be made up of exceedingly minute spiculæ, closely aggregated.

Magnesia. — With borax, magnesia yields quite readily elegant, acicular crystals, almost invariably united in tufts, or sheaf-like bunches. (See Plate, Fig. 4.)

With microcosmic salt, microscopically small crystals are produced by slight flaming, sometimes possessing a stellate form, and sometimes being rectangles approaching the square. The reaction with borax, I regard as by far the most decisive.

Alumina. — With borax, alumina dissolves to a limpid glass, which is not rendered opaque by saturation or flaming. When more of the earth is present than can be dissolved by the flux, prolonged blowing

produces a white, vitreous-looking exudation at the margin of the bead, which is hard enough to scratch glass, and is not easily soluble in borax. Keeping the bead a long time at a high temperature produces the same effect, even when the glass is not saturated; and the same thing occurs when this earth is treated with microcosmic salt.

With microcosmic salt, patient flaming is rewarded by a very slight precipitate, consisting of an immense number of exceedingly minute, asteriated crystals, partaking of the snow-flake character, but not nearly so well defined and symmetrical as the crystallizations of baryta with the same flux.

In borax, mixed with an equal quantity of lime, I have obtained crystals; but of a very irregular form, and unfinished appearance. It should be borne in mind, however, that I have not been able to crystallize either of these earths *alone* in borax.

Glucina. — With borax, an exudation, similar to that noticed with alumina, takes place upon long heating. Flaming produces a precipitate composed of colorless globules or bubbles. Mixed with an equal quantity of lime, a similar precipitate is obtained.

With microcosmic salt, upon flaming, the surface of the bead becomes studded with crystals, but so minute as to require a high magnifying power to discern their form. They are generally rather slender, solitary, oblong figures; but quite often cruciform, and sometimes irregularly assembled.

Zirconia. — In borax, the intermittent flame causes a crystalline precipitate; but the individual forms are too minute to be distinguished, when magnified four hundred diameters. Long blowing produces the exudation observed with the two preceding earths. Addition of lime, in very considerable quantity, causes a very decided precipitate upon flaming, consisting of bubbles. The zircon, from which the earth used was prepared, gave a similar precipitate to that last named, but much less dense.

With microcosmic salt, flaming is followed by the formation of an indistinct, crystalline film.

Zinc. — Oxide of zinc, with borax, yields, in the intermittent flame, acicular crystals, arranged in tufts, asteriated, and sometimes arborescent. These crystals resemble those of magnesia in the same flux, except that I have not observed either the stellate or arborescent arrangement with the latter. In the reducing flame a bright metallic precipitate, flesh-colored to brassy, is easily obtained, after adding oxide

of copper, thorough fusion in the outer flame, and refrigeration of the bead.

With microcosmic salt, crystals are formed, in the intermittent flame, which I am inclined to regard as flattened octohedrons.

Cadmium. — With borax, in the intermittent flame, oxide of cadmium gives crystals much like those of zinc and magnesia, except that the tendency to a stellar arrangement is more marked than with either of the last-mentioned substances. In the reducing flame, oxide of copper being previously added, the precipitate is similar to that observed with zinc, but not so brassy, and bordered, moreover, on the edge from the flame, by iridescent bands, which I have not observed with zinc.

In microcosmic salt, it crystallizes in rectangles, one diameter being two or three times greater than the other. The crystals are quite minute, and, generally, transparent.

Lead. — With borax, and treated in the intermittent flame, litharge gives a precipitate consisting of microscopically minute spheres, darker than the globules mentioned as occurring with some of the earths; and associated with which I have noticed a few prismatic crystals, so small as to be scarcely distinguishable, even when magnified four hundred diameters. Slightly heated in the reducing flame, a dark-gray, lustreless, amorphous precipitate appears on the surface of the bead.

With microcosmic salt, the phenomena, with the intermittent flame, are much the same as when borax is employed, except that, in most instances, the precipitate is crystalline rather than globular.

Bismuth. — Oxide of bismuth does not crystallize, in the intermittent flame, with borax, but yields globules like those of lead. Touched with the reducing flame, I have observed a slight, amorphous precipitate on the surface of the glass; but not nearly so dark, or distinct, as that of lead. With litharge, a partially metallic precipitate is obtained. With oxide of copper, the precipitate resembles that of zinc, though, perhaps, somewhat less lustrous.

With microcosmic salt, it crystallizes in very small, square, transparent disks, when treated in the intermittent flame. A considerable number of globules, like those observed in the borax beads, accompany the crystals.

Antimony. — In borax, teroxide of antimony yields no precipitate, either with the intermittent or reducing flame, although they both produce a peculiar corrugation on the surface of the glass. Addition of

litharge is followed by the appearance of an apparently insoluble substance, in the glass, which renders it opaque without devitrification taking place; but the reducing flame does not produce a precipitate in a bead thus treated. When teroxide of antimony is added, in considerable quantity, to a bead colored dark blue with oxide of copper, and just removed from the oxidating flame, it is at once taken up by the still fluid glass, in which an amorphous, red precipitate—apparently sub-oxide of copper—is immediately formed. When the copper bead is a very dark, nearly opaque, blue, addition of much teroxide of antimony converts it, *after fusion in the outer flame*, into a parti-colored enamel, in which red and yellow predominate; and the bead, upon cooling, loses its uniform convexity of outline, the surface becoming very irregular. Treated in the reducing flame, a rather indistinct, dull-gray looking precipitate is then obtained. When much less teroxide of antimony is present, the precipitate is not unlike that of zinc, though it is, in most cases, accompanied by a red border of sub-oxide of copper, which I have not noticed in the zinc beads.

With microcosmic salt, I have noticed an amorphous precipitate on the surface of the glass, when treated in the reducing flame, which was, in one case, accompanied by solitary, needle-like crystals, distinguishable by the lens.

Arsenic.—With the intermittent flame, I have not obtained crystals in either flux.

Addition of arsenious acid to a hot borax bead, colored dark blue with oxide of copper, is immediately succeeded by the formation of a precipitate similar to that just described under the head of antimony; but in no case, however large be the quantity of arsenious acid added, does the bead lose its form, or assume the colors of the antimony enamel, after being reheated in the outer flame. The precipitate in the reducing flame is principally sub-oxide of copper, accompanied sometimes, however, by brassy-looking, metallic particles. With sesquioxide of iron, there is a rather scanty precipitate, in the reducing flame, in color and lustre not unlike metallic arsenic.

Tin.—In borax, binoxide of tin yields a very slight, filmy precipitate, in the intermittent flame, made up of exceedingly transparent, but very indefinitely shaped crystals, which, viewed under the microscope, bring forcibly to mind a pellicle of recently formed ice floating in clear water, the corrugations of whose surface alone serve to distinguish it from the fluid on which it rests.

With oxide of copper, and treated in the reducing flame, the precipitate closely resembles that of zinc under the same circumstances.

With microcosmic salt, I have observed no crystallization.

Silver.—Oxide of silver, fused with borax in the outer flame, to a clear glass, and treated with the reducing flame, gives a yellowish precipitate of very minute crystals, of which the form appears to be octohedral; and with microcosmic salt, the reaction is similar.

Addition of considerable oxide of silver to a bead containing litharge renders it opaque, and of an oil-yellow color. Treated in the reducing flame, there is a precipitate of what appears to be metallic silver, in minute globules and irregularly shaped masses. The part of the bead acted upon likewise becomes straw-colored, and slightly iridescent. When oxide of copper is substituted for litharge, the bead becomes opaque, and of a light greenish-blue color. Touched with the reducing flame, the part within its influence changes to a very beautiful pale blue, bordered by bands of a somewhat cupreous shade, and enriched by a fine play of colors. A precipitate resembling metallic silver frequently accompanies this reaction. With oxide of nickel, in the outer flame, a grayish-brown, streaked enamel is produced. The reaction with the reducing flame slightly resembles that with copper; but the bands around the part heated are very light,—almost white, in fact,—and the delicate pale blue of the copper reaction is entirely wanting. With teroxide of antimony, in the reducing flame, there is a metallic precipitate. Addition of litharge to the silver-copper and silver-nickel beads, and treatment with the reducing flame, produces a metallic precipitate, in the form of globules distinguishable with the lens.

Copper.—Oxide of copper, with borax, and treated as just described under silver, yields a metallic precipitate, which is somewhat increased by addition of litharge.

With microcosmic salt, there is a similar precipitate, accompanied sometimes by the formation of sub-oxide of copper.

By means of the reaction with borax, I have detected copper—obtaining a metallic cupreous precipitate, in an iron pyrites, said to contain but two or three per cent of that metal; and where the proportion of copper was so small, that it did not affect the characteristic iron-yellow of the glass when heated in the outer flame.

Nickel.—With borax, oxide of nickel gives a gray, metallic precipitate, when heated in the reducing flame. Addition of litharge renders

the precipitate somewhat globular. Arsenious acid does not seem materially to affect the character of the precipitate; nor do the sesquioxides of iron and chromium, and the red oxide of manganese. With equal parts of the oxides of nickel and copper, the color of the precipitate indicates the presence of both metals, in some parts the cupreous, and in others the nickelic hue prevailing. Where the oxide of copper is very considerably in excess of the nickel, the precipitate has still a decidedly grayish cast; but when the latter oxide is in excess, the presence of copper is scarcely perceptible, aside from the blue color it imparts to the glass.

With microcosmic salt, the reactions are similar to those described with borax; but not so easily obtained, owing, perhaps, to the greater fluidity of glasses made with that flux.*

Cobalt.—With borax, oxide of cobalt, in the reducing flame, gives a gray metallic precipitate, not distinguishable from that of nickel. Arsenious acid causes a larger precipitate, but does not affect its appearance. Sesquioxide of iron seems to promote the precipitation of the cobalt. With an equal amount of oxide of copper, the precipitate is cupreous, inclining to gray, the latter shade being best recognized by comparison with a pure copper precipitate.

Manganese.—In a borax bead, highly colored by oxide of manganese, but still translucent, a scanty dark-colored precipitate is obtained in the reducing flame; but this precipitate is not metallic, and seems to be *within* the glass rather than on its surface. Lime seems to hasten this reaction; and after adding this substance I have noticed a crystalline precipitate form upon flaming. The crystals were transparent prisms, quite large, and apparently modified.

With microcosmic salt, in the reducing flame, there is a crystalline precipitate, composed of spiculæ, bearing some resemblance to those of lime, only rather larger and more conspicuous than any I have observed with that earth.

Iron.—Sesquioxide of iron, fused with borax, in the outer flame, to a dark, brownish-yellow bead, and then treated with the reducing flame, affords an amorphous precipitate, in streaks and reticulated

* In treating pyritic minerals, they should be carefully roasted before fusion with borax, otherwise a precipitate of sulphide of iron may occur, which somewhat resembles the metallic precipitates of Nickel and Cobalt, and might be mistaken for one of those metals, thereby misleading the operator as to the constitution of the substance under examination.

aggregations, which appear black by transmitted, and grayish-black by reflected light. When the bead saturated with iron is heated for some time in the ordinary *reducing* flame, and, when quite cold, a small portion of its surface exposed for a few seconds to the influence of the small fine-pointed *reducing* flame, the precipitate which forms is apparently metallic. When a bead, nearly opaque with sesquioxide of iron, is thoroughly fused in the outer flame, teroxide of antimony added, and then reheated for a short time in the *same* flame, a gray metallic-looking precipitate forms on the surface, upon cooling. Substituting arsenious acid for antimony, the experiments otherwise being conducted in the manner just described, I have obtained no precipitate whatever. Lime and litharge seem to have but little effect on the iron reaction. Upon adding the red oxide of manganese, I have noticed a dark cloudy precipitate form in the glass, after treating with the reducing flame; but the reaction is very unsatisfactory.

Uranium. — With borax, in the *intermittent* flame, sesquioxide of uranium yields a light-colored flocculent-looking precipitate; but no crystals, so far as I have observed. In the reducing flame, the precipitate is very much like that of iron; and addition of sesquioxide of iron, or lime, does not sensibly affect it. Manganese produces, in the reducing flame, the same precipitate that it does with iron.

In microcosmic salt, I have obtained a crystalline precipitate; but the form of the crystals was not determinable, when magnified four hundred diameters. This precipitate formed only after repeated applications of the *reducing* flame. Upon adding sesquioxide of iron, I noticed crystals, in outline like those of strontia, but much smaller than any that I have seen of that earth.

Chromium. — Sesquioxide of chromium, fused with borax in the outer, and then treated with an *intermittent inner* flame, yields a glass filled with bubbles which are often microscopic. Reversing the process, viz. first treating with the reducing flame, is followed by the same result. With microcosmic salt, I have not obtained any different reaction. Berzelius alludes to this phenomenon, in his treatise on the blowpipe, stating at the same time his inability to account for it.

Tungstic Acid. — With borax, in the reducing flame, tungstic acid readily yields a crystalline precipitate, often bluish at the edges, and slightly iridescent. Under the microscope, this precipitate strikingly resembles the arborescent crystallizations of frost upon window-glass

(see Plate, Fig. 5); and, when viewed by reflected light, it exhibits a frosty lustre. Mixed with an equal quantity of sesquioxide of iron, the tungstic acid reaction is easily obtained, and quite apparent, in a translucent glass; but where the bead is opaque from excess of iron, a slight grayish precipitate only is distinguishable. Silicic acid seems to promote the formation of this precipitate, even when added in large quantities. Equal parts of tungstic acid and oxide of copper give a cupreous precipitate, but decidedly grayish.

With microcosmic salt, the reactions are much the same as with borax; except that in a transparent bead containing a mixture of sesquioxide of iron and tungstic acid I have noticed, besides the arborescent variety, crystals of a hexagonal stellate form, one of the axes being, however, at least one half longer than the others, thus giving to the crystals a distorted aspect.

Titanic Acid.—In borax, treated with the reducing flame, titanic acid affords an amorphous, blue precipitate, usually as a band stretching across the surface of the bead. Mixed with equal parts of tungstic acid, in the reducing flame, the reaction of the last-named acid is very apparent, while that of titanic acid might easily be confounded with the blue border mentioned as frequently accompanying the tungstic acid precipitate; though I am inclined to think that the presence of the titanic acid renders the blue color deeper and more distinct. An excess of titanic acid gives a blue band, too well defined to be easily mistaken for any similar appearance of tungstic acid; yet the reaction of the latter is quite apparent, even when the former is three or four times in excess. Mixed with sesquioxide of iron, avoiding an excess of iron, however, the blue titanic acid precipitate is easily obtained and recognized, the glass being still translucent. When the quantity of sesquioxide employed was six or seven times that of the acid, I obtained a very dark iron-gray precipitate, on the surface of an opaque bead. Equal parts of titanic acid and oxide of copper yield a slightly gray copper precipitate.

With microcosmic salt, in the reducing flame, titanic acid gives a transparent, colorless crystalline precipitate.

Molybdic Acid.—With borax, in the reducing flame, molybdic acid yields quite easily a lustrous, iridescent metallic precipitate, in color from silver-gray to black, and bordered, on the side remote from the flame, by a brown band. In the portion of the glass not obscured by this precipitate I have noticed transparent hexagonal and rhomboidal

crystals, (see Plate, Fig. 6,) accompanied by very irregularly shaped, but equally transparent, crystalline masses. In mixtures of equal parts of molybdic acid and oxide of copper, the copper precipitate is somewhat inclined to gray. With sesquioxide of iron, there is a black metallic-looking precipitate, not iridescent. When the iron was considerably in excess, the precipitate was slight, and difficultly obtainable. In presence of manganese, the precipitate was quite dense, and simply characteristic of molybdic acid; and such was also the case in mixtures of equal parts of molybdic and tungstic, and molybdic and titanitic acids.

With microcosmic salt, I have obtained a precipitate similar to, but less distinct than, that noticed with borax.

CONCLUDING REMARKS.

Beads, at a certain point of saturation, will become wholly or partially opaque upon cooling; and, under such circumstances, well-defined crystalline forms are sometimes produced; but they are generally obscured by the increase of the devitrified portion of the glass, during the process of cooling. In two or three instances, however, while experimenting with baryta, I have observed distinctly marked hexagonal crystals form *beneath* the surface of the glass (when obtained by the reheating or flaming process, the crystallizations are quite close to the surface), as it cooled after complete fusion, prior to flaming, without any further devitrification taking place; and the crystals of Fig. 1 of the plate are examples of this kind.

Wherever mention is made in the foregoing pages of treatment with the "reducing flame," the short, fine-pointed flame of the diagram, described in the commencement, is intended, except in one or two cases, where the "whole surface of the bead" is spoken of as being acted on by the reducing flame; and *previous fusion in the oxidating flame, and cooling of the glass, is always presupposed*, unless a different method of procedure is explicitly stated. An "intermittent reducing flame" is also alluded to, and by this is meant repeated applications of the fine jet of flame, time being allowed between each application for the bead to cool. This method will often insure a precipitate where a single heat would altogether fail, which is especially apt to be the case in glasses not very highly charged with the subject of experiment; for, it must be borne in mind, it will not do to heat the bead too long at any one time, when a precipitate by reduction is desired, as the precipitate

ordinarily forms at or near the margin of the red-hot portion of the glass, the tendency seemingly being to aggregate away from the point of greatest heat, and in a matrix which has not assumed the fluid condition. In consequence of this tendency, if the heat be too long continued—which may be known by the reddening of the whole or greater part of the surface of the bead—the precipitate, especially when scanty, is driven completely off the glass and thrown upon the wire loop, where it is often invisible, besides exercising, if in the metallic state, a damaging influence on the wire itself. Frequently the precipitate is in the form of a narrow, crescent-shaped band, at the edge of the heated portion of the glass; and repeated cautious applications of the flame will generally produce a repetition of these bands; thus rendering quite distinct what otherwise might scarcely have been visible.

Where the precipitate is metallic, translucency of the glass is not important, and, unless microscopic study is intended, rotundity of the bead is not objectionable; on the contrary, within certain limits, is preferable, on account of its being more slowly heated, and thus allowing a more prolonged action of the flame.

In reference to the mixtures experimented on, where the proportions are given, bulk, not weight, is to be understood. Many and carefully conducted experiments are needed to determine the constancy and delicacy of the reactions I have described, to say nothing of the multitude of combinations which remain untried. The subject of combinations suggests the possibility of finding certain substances which, when brought together under the influence of the fluxes, and of the different blowpipe flames, shall give decisive evidence of the presence of one or both of them, when, perhaps, alone they would wholly have escaped detection in this method of chemical investigation, and as bearing on this point, the reactions of antimony and arsenic with oxide of copper, that of the former with iron and of alumina with lime, are especially worthy of attention.

The following extracts from Muspratt's "Chemistry, as applied to Arts and Manufactures," pages 194 and 197, Art. "Devitrified or Semi-crystallized Glass," cannot fail to be of interest in connection with the subject of crystals in blowpipe beads:—

"As excessive brittleness results from the sudden cooling of glass, so, on the other hand, when the fused metal is cooled too slowly, the amorphous state entirely disappears, the mass assumes a crystalline structure, and other changes occur which are termed *devitrification*.

If the glass contains different bases, a partial separation takes place; the silica divides itself between the bases, and thus forms compounds of definite proportions which crystallize separately. In this case the intimate mixture of the materials which constitute the true glass is destroyed; the glass becomes *very hard, fibrous, opaque, much less fusible, a better conductor of heat and electricity.*"

"'To sum up,' in the words of Dumas, to whom the editor is chiefly indebted for what has been said on this interesting subject, '*devitrification is a crystallization of glass, due to the formation of definite compounds infusible at the temperature existing at the instant of devitrification.* Sometimes this infusibility is produced by the volatilization of the alkaline base; sometimes by a single division or separation, the alkali then passing into that portion of the glass which preserves the vitreous state. All glasses may therefore be devitrified, for all glasses are capable of passing to the state of definite, and consequently crystallizable, silicates. Glasses which contain at the same time indifferent oxides and basic oxides will devitrify better than others, by the tendency which the indifferent silicates and basic silicates have to combine in definite proportions. Lastly, devitrified glasses will possess very variable properties, for their composition itself will differ completely, according to the nature of the glasses and the circumstances of devitrification. Thus sometimes the devitrified glass will be crystallized in needles of considerable size, as happens with window-glass; sometimes it will be crystallized in very fine needles, or even simply transformed into an opaline mass, without appearance of crystals, as in the case of bottle-glass.'"

SUPPLEMENT.

Since the preceding pages were prepared for publication, I have been enabled, through the kindness of Dr. Gibbs and Prof. Cooke, to submit Niobic Acid, Selenium, Tellurium, and Protoxide of Cerium to the methods of blowpipe examination, of which I have just treated, and with the following results.

Niobic Acid.—Niobic Acid (Nb_2O_5), with borax, after fusion in the outer flame, gives easily, either in the intermittent or fine-pointed reducing flame, a whitish precipitate, tinged with blue, yellow, and violet, and remarkably iridescent by transmitted as well as by reflected light. I have observed no crystals in this precipitate; but highly magnified, it is resolved into minute spheroidal-shaped masses. The precipitate is the same in the reducing as in the intermittent flame, and

is liable to be confounded with that given by titanitic acid when treated with the intermittent flame, unless submitted to microscopic examination, when it is easily distinguished, the titanitic acid precipitate being amorphous matter, sometimes presenting a reticulated structure, but never, to the extent of my observation, either in numerous distinct points or spheroidal.

When a small proportion of tungstic acid is present, both it and niobic can easily be distinguished, though in this case the *reducing* flame sometimes produces an amorphous precipitate not unlike that of titanitic acid, but subsequent treatment with the *intermittent* flame will bring out the characteristic spheroids of niobic acid.

Mixed with titanitic acid, niobic acid being in excess, the precipitate shows traces of the presence of the former acid; but the reaction is not nearly so definite or delicate as that just described with tungstic acid.

Manganese seems to facilitate the precipitation of niobic acid.

Columbite, from Middletown, Connecticut, gives the niobic acid precipitate, though the presence of iron detracts from its iridescence as viewed by transmitted light.

With microcosmic salt, there is a slight amorphous, brownish-yellow precipitate.

Selenium. — Fused with borax in the outer flame, the selenium glass, when very slightly touched with the reducing flame, gives minute, transparent, spindle-shaped crystals, forming apparently a crust on the surface of the bead. These crystals closely resemble those of selenious acid formed when selenium is heated in the closed tube.

With microcosmic salt I have obtained no reaction, the glass being exceedingly fusible.

Tellurium. — Its reaction is like that of selenium, except that with microcosmic salt I have observed crystals similar to those obtained with borax.

Protoxide of Cerium. — With borax, both in the reducing and intermittent flames, I have noticed a granular, crystalline precipitate. The crystals are very minute, and with the microscopic facilities at my disposal, I have not been able to determine their form, though of their *crystalline* character I think there can be no doubt, except in cases where the reheating process has been too much prolonged, when they appear to lose their angular structure, and sometimes fuse together to a mass not unlike the precipitate of titanitic acid in the reducing flame.

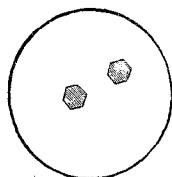


Fig. 1. Ba O.

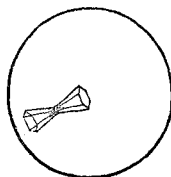


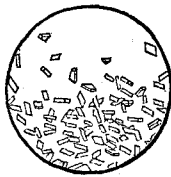
Fig. 2. Ba O.



Fig. 3. Sr O.



Fig. 4. Mg O.

Fig. 5. W O₃.Fig. 6. Mo O₃.

Explanation of the Figures.

Fig. 1. Baryta in microcosmic salt (obtained without flaming).

" 2. Baryta in borax.

" 3. Strontia in microcosmic salt.

" 4. Magnesia in borax.

" 5. Tungstic Acid in borax.

" 6. Molybdic Acid in borax.

Five hundred and fiftieth Meeting.

April 11, 1865. — MONTHLY MEETING.

The PRESIDENT in the chair.

Mr. Alexander Agassiz read a paper on the young of a species of *Planaria*.

Five hundred and fifty-first Meeting.

April 25, 1865. — SPECIAL MEETING.

The PRESIDENT in the chair.

Professor Lovering presented a report from the Rumford Committee, recommending that the Rumford Premium be awarded to Professor Daniel Treadwell for improvements in the management of heat, and the subject of the report was assigned as the special business of the meeting on the second Tuesday of May.

Professor Cooke made the following communication : —

An accident to one of the large turbine wheels employed by the Merrimack Manufacturing Corporation of Lowell has furnished a most remarkable illustration of the modern mechanical theory of heat, and through the kindness of Mr. Isaac Hinckley, the accomplished agent of the Corporation, I have the pleasure of bringing the facts to the notice of the Academy. I cannot do better than to begin by reading Mr. Hinckley's own statement, in a letter addressed to me, dated December 30th, 1864. The specimens referred to in the letter I have placed on the table for the inspection of the Academy.

"In accordance with your request, I herewith send you five pieces of metal, once portions of one of our turbines. I have placed these pieces in the box in the same relative positions which they occupied when they made a part of the turbine. To make my statement clear to you, I would refer to Plate I. of Mr. Francis's admirable work, 'Lowell Hydraulic Experiments,' which you will find in the College Library. Our turbines are similar to the Tremont turbine therein shown.

"The turbine of which these pieces were a part is one of 250 H. P., under a fall of 32 feet, using 75 cub. ft. of water per second. The wheel is of 58½ inches diameter, with depth of float of 6 inches, and a velocity

of 144 revolutions per minute. Its position is horizontal, and at a level of 3 feet below the surface of Merrimack River at its ordinary stage. It is mounted upon a vertical wrought-iron shaft 25 feet long and 6 inches diameter at smallest place. This shaft is fitted at its upper end with a series of disks, by means of which it is supported in its box, which again is supported by a massive cast-iron frame. This frame supports the entire weight of the wheel and shaft. The shaft at its lower end is bored in the line of its axis to a depth of $5\frac{1}{2}$ inches to receive a steel pin of $17\frac{1}{2}$ inches length and $2\frac{1}{2}$ inches diameter; and which projects from the shaft 12 inches. The steady-pin has no function to perform other than that of restraining the shaft from lateral aberration. It is free to revolve in a box made of three pieces of case-hardened iron, so placed in a cast-iron frame as to allow free play to the steady-pin and the free access of water to it. Each of these three pieces composing this box is kept up to its place by following-screws working in the cast-iron frame which is bolted to the stone floor of the turbine pit. In the Tremont turbine this floor is of wood, and in Plate I. the steady-pin is marked 'I.'

"The pieces sent are marked Nos. 1 to 5. No. 1 is the portion of the steady-pin which was nearest the shaft; No. 2, the other extremity of the same pin; Nos. 3, 4, 5, the three pieces of case-hardened iron forming the box, with portions of the steady-pin attached. You will at once perceive that this steel has been partially fused, and can thus account for its attachment to the iron.

"The facts are, that on noticing some irregularities of motion on the part of the wheel, it was stopped, and the water pumped from the pit until the floor was bare. Inspection showed that the following-screws had not done their duty uniformly; and the three pieces, Nos. 3, 4, 5, no longer preserved their proper relative positions, nor allowed free play to the steady-pin. The consequence was, an amount of friction causing heat sufficient to fuse steel, although the latter was immersed three feet deep in a raceway ten feet wide, through which was passing seventy-five cubic feet of water per second.

"A similar accident happened thrice to our turbines, which are now, however, safely guarded against such mishaps."

There are two points in connection with these facts to which I wish especially to call attention. In the first place, the weight of the wheel did not rest upon the surfaces of friction. The three pieces of case-hardened iron in their displaced position acted simply as a brake

upon the revolving shaft, so that the heat must have resulted wholly from the destruction of mechanical motion. The immense moving power of the wheel, instead of being directed wholly into its appropriate channel, was in part transformed into that mode of atomic motion called heat. In the second place, the temperature attained was at least the welding-point of iron, and this, too, although the heated metal was immersed in a stream of flowing water. It is undoubtedly true, that the spheroidal condition of the water would greatly retard the loss of heat, but still the loss must have been exceedingly rapid. Now the loss, even at the highest temperature attained, must have been fully supplied by the heat generated during the same time; and this must, therefore, have been evolved with equal rapidity at the surfaces of friction. No change in the molecular condition of the iron, and no abrasion of the metal, is at all sufficient to account for this continuous, prolonged, and immensely rapid evolution of heat, and the facts force upon us the conclusion, that the destruction of mechanical motion is the one and only efficient cause. Moreover, if we admit the generally received principle of mechanics, that motion cannot be annihilated, the conclusion that heat is a mode of motion is equally irresistible. Lastly, it is evident that the facts here stated perfectly accord with the well-known experiments of Rumford and Davy; only since the moving power of the Merrimack turbine is so much greater than that employed by these distinguished experimentalists, the results which I have had the pleasure of exhibiting are more striking and conclusive than any which have been previously obtained.

Five hundred and fifty-second Meeting.

May 9, 1865. — MONTHLY MEETING.

The PRESIDENT in the chair.

The Recording Secretary read letters relative to exchanges. The proposition of the Rumford Committee, that the Rumford Premium be awarded to Professor Treadwell for his improvements in the management of heat, which had been referred to this meeting, was then brought up for discussion, and was referred to the Annual Meeting for the action of the Academy.

Five hundred and fifty-third Meeting.

May 30, 1865. — ANNUAL MEETING.

The PRESIDENT in the chair.

The Report of the Council upon the changes which had occurred in the Academy during the past year was presented and read by the Corresponding Secretary, as follows: —

In our annual survey of the changes which have taken place in the membership of the Academy, our thoughts naturally turn in the first instance to the losses which we have sustained by death. These, although less numerous by one half than in the year preceding, are still severe.

The four names which now disappear from the roll of Resident Fellows are those of Messrs. *Bartlett* and *Bond* of the first Class, of *Everett* and *Quincy* of the third; — two taken from us in their prime, and two in the fulness of years and honors.

Only two Associate Fellows have deceased, the astronomer *Gilliss*, and the venerable *Silliman*; and only one Foreign Honorary Member, the venerable astronomer *Struve*.

Taking into view the important services rendered to Astronomy by Messrs. Quincy and Everett, it will be noticed that the losses of the past year fall peculiarly upon that department of science.

WILLIAM PITT GREENWOOD BARTLETT, one of the youngest members of our mathematical section, died at Cambridge on the 13th of January last, just as he was entering upon a promising scientific career. He was born at Boston, on the 27th of October, 1837, entered Harvard University in the summer of 1854, and graduated with honors in July, 1858. He soon entered into the corps of computers for the American Ephemeris, and was assiduously engaged in this work until his decease. He contributed to Runkle's Mathematical Monthly some valuable papers on the elements of Quaternions, and to the Memoirs of this Academy a paper on Interpolation. In the Nautical Almanac Office he had charge of the Time-stars and the Circumpolar Stars; and he showed great ability and industry in preparing their Ephemeris and tables. The character of his work is highly eulogized by the simple statement of the fact, that it was left in such condition that another computer could take it up, without the loss of any of Mr. Bartlett's labor, at the point where it was dropped through the sudden and fatal illness by which a life of great promise was cut short.

GEORGE PHILLIPS BOND, the worthy successor of his father, the first director of the Cambridge Observatory, died, of consumption, on the 17th of February last, a few months less than forty years old. He was born at Dorchester, on the 20th of May, 1825, and was graduated at Harvard University in the summer of 1845. He began to make observations as early as the year 1842, at the temporary Observatory on Quincy Street, where he soon took the place of his deceased brother, W. C. Bond, Jr., a young man of high promise as an astronomer. After graduation, and upon the permanent establishment of the Observatory, George Bond took the post of Assistant Observer, which he held until 1859, when, upon the death of his lamented father, he was called to succeed him as Director. Thus his whole life, even from boyhood, was devoted to astronomical labors in connection with the Observatory which the Bonds, father and son, have made illustrious. Upon them devolved the heavy task of organizing the new establishment, and of carrying it on with means in slender proportion to its work. Suffice it to say, that the high position which the Observatory took under the direction of the elder Bond was maintained under the younger. To its interests, and to scientific labors in connection with his official duties, he gave himself, from first to last, with entire devotion.

The most important of his scientific investigations are : —

1. Those relating to the mathematical theory of some portions of Astronomy, especially his papers on Cometary Calculations, and the Method of Mechanical Quadratures (in which he anticipated a valuable improvement afterwards given independently by Encke), and that on the use of Equivalent Factors in the Method of Least Squares. To this category belong in part his investigations upon Saturn's rings, which form the first step towards the present state of the problems connected with that system.

2. The Reduction of the Observations made for the United States Coast Survey Chronometric Expeditions between Cambridge and Liverpool, effected under his direction. Upon these depend the most trustworthy American longitudes.

3. The Observations of Zones of small Stars. He mainly prepared the plan for observing and reducing these zones, and even graduated the mica scales employed in them. He also made many of the observations, — the most of the published portion, and a large share of those still in manuscript.

4. The two works on the Comet of Donati and the Nebula of Orion are, however, his most important contributions to astronomical science. The former commanded the general admiration of astronomers as a full and faithful monograph of the physical phenomena of that celebrated comet, and was crowned with the highest honors by the Royal Astronomical Society in the recent award of its gold medal. The latter work, — understood to be complete as to the researches, but the exposition of which his waning strength did not permit him to finish, — it is hoped may, in the main, yet be given to the world, to vindicate the essential accuracy of his father, and to reflect additional lustre upon his own memory.

The spirit and personal characteristics of Professor Bond may be expressed in few words. He was a remarkably patient and industrious as well as skilful investigator, and was ever anxious that his works should possess the qualities, now so imperatively demanded, of unity and completeness. That he did so much for science, and did it so well, during the few years that were allotted to him, must have been partly owing to an extreme reluctance to dissipate his powers by beginning new works while old ones were still unfinished. Science to him was not a pastime, but a serious calling, to be pursued with utmost conscientiousness and singleness of purpose. These characteristics were strikingly exemplified in the latter months of his life, in the perseverance and earnestness with which, under great physical weakness and constant suffering, he continued to the last his work upon the nebula of Orion, dictating to and directing his amanuenses long after the strength to write was gone from him. He was ever watchful of the interests of the institution committed to his charge, and strict in the performance of every duty. All who knew him well can testify to the great simplicity, purity, and uprightness of his character. He was deeply penetrated with the spirit of Christianity, and was a devout member of the Episcopal Church.

He visited Europe first in 1851, and again in 1863. In 1851 he observed the total eclipse of that year in Sweden, and visited the principal Observatories of the North of Europe. In 1863 he spent a few months in England and Germany, renewing personal intercourse with old friends and correspondents, and forming new ties, too soon, alas! to be severed.

EDWARD EVERETT was born in Dorchester, Massachusetts, on the 11th of April, 1794, and was graduated at Harvard University with

the highest honors in 1811. In 1812 he was appointed Latin tutor at the University. Meanwhile he had devoted himself to the study of Divinity, and in 1813 he was installed as pastor of Brattle Street Church in Boston. In 1815 he was elected Professor of the Greek Language and Literature at Cambridge, and soon afterwards embarked for Europe to prepare himself, by study in Germany, and by travels in Greece and other parts of the Old World, for the duties of this Professorship. He had hardly entered on his twenty-first year when he was thus called to quit the clerical profession ; but he had already won the highest reputation as a pulpit orator, and in 1815 had published an elaborate defence of Christianity, in a volume of five hundred pages, which would have done no discredit to the most mature theologian of the time.

Returning from Europe in 1819, he proceeded at once to the discharge of his duties as Greek Professor in Harvard University, where he acquired fresh distinction both as an orator and a scholar by his brilliant lectures on Greek literature. He found time also to publish a Greek Grammar translated by himself from the German of Buttmann, and a Greek Reader based upon that of Jacobs. In 1820, while still holding this Professorship, he assumed the editorial charge of the *North American Review*, to whose pages during the four following years he contributed about fifty articles. Fifty or sixty articles were contributed by him to the same *Review* in subsequent years after he had ceased to be its editor.

In 1824, Mr. Everett was chosen a Representative from the Middlesex District in the Congress of the United States, and continued to serve his fellow-citizens in that capacity for more than ten years. His eloquent speeches on almost all the great political questions of that period, and his able reports as chairman of the Committee of Foreign Affairs, would have been enough to secure him a permanent national reputation, had this been his only sphere of public service.

In 1835, Mr. Everett was elected Governor of Massachusetts, and held that office with great dignity and distinction for four years. Failing of a re-election by only one vote, he embarked for Europe in 1840 with a view to his own health and that of his family, and not without plans of literary labor which he hoped to accomplish in Italy. There is the best reason for thinking that "Rome in the Times of Cicero" was the subject of a work which he had proposed as the occupation of the period of his residence abroad. But public employment was again

destined to interrupt his literary labors. In 1841, he was appointed to represent his country at the Court of St. James, where he remained for four years as Minister Plenipotentiary, and where he found an ample field for displaying his abilities as a diplomatist as well as his accomplishments as a scholar and his eloquence as an orator.

Returning home in the autumn of 1845, Mr. Everett was met with the appointment of President of Harvard University. He accepted this office with reluctance, but he administered its difficult duties with the greatest assiduity and ability for three years, when the state of his health compelled him to resign it.

In 1852, on the death of Mr. Webster, Mr. Everett was summoned to Washington as Secretary of State of the United States, and conducted the foreign affairs of the country with great brilliancy during the brief term which remained before the expiration of President Fillmore's administration.

In 1853, he was elected a Senator of the United States for six years by the Legislature of Massachusetts, but his health proved insufficient for the arduous labors of Congress during that exciting period of our national affairs, and in the summer of 1854 he resigned his seat, and retired finally to private life.

This summary statement of Mr. Everett's official career, distinguished and varied as that career was, furnishes, however, a very inadequate idea of his life and labors even during the years to which it relates. While he always discharged the duties of the successive offices to which he was called with conscientious and most exemplary fidelity, he by no means confined himself to the mere routine of official service. On the contrary, it was during this very period that he achieved the highest distinction as a scholar and an orator by efforts quite apart from the duties of public station. In the three noble volumes of his works already published there will be found nearly a hundred orations, speeches, or lectures, upon almost every variety of topic, moral, historical, literary, or scientific, delivered during these thirty years of his official career, from 1824 to 1854, hardly one of which has any relation to the offices which he held. They were purely labors of love, superadded to those of office, and undertaken voluntarily in the cause of popular education and improvement. It is hardly too much to say, that had Mr. Everett held no office during this whole period, the record of his life would still have exhibited an amount of work done, and admirably done, which would have insured him a most grateful remembrance and a most enviable reputation with posterity.

Nor was the private life of Mr. Everett, when he finally withdrew from all official position, a life of retirement or inaction. Indeed, it may be doubted whether he was ever more actively or more successfully employed in serving the public than during the last ten years of his life, when he was free from all official obligations. As President of the Board of Trustees of the Public Library of Boston, and as one of the Overseers of the University at Cambridge, he continued to render the most valuable aid to the cause of popular education. As a lecturer before many of our mercantile, literary, and charitable associations, as a speaker at almost all our great anniversary festivals and occasional meetings, and as a contributor to the public journals of his own or other cities, he found ample opportunities for expressing his views on the various questions of the day, (and he expressed them with more independence and more weight as a private citizen of the highest accomplishments and largest experience, whom all honored and respected, than if he had held the most important and distinguished office in the gift of the people.) Among the public addresses delivered by him at this period of his life, there is, perhaps, none of more commanding excellence than the one which he pronounced in August, 1856, before the American Association for the Advancement of Science, on the occasion of dedicating the Dudley Astronomical Observatory, — a discourse which for felicity and scope of illustration and for effective oratory may well be ranked among the most brilliant of the contributions which science owes to literature and eloquence. During a portion of this period of his private life he devoted himself particularly and with the greatest success to the collection of a fund for the purchase of Mount Vernon, and for securing the home and the grave of Washington as the property of the nation. To this end he visited almost all the great cities of the Union, delivering a brilliant discourse on the character of the Father of his Country wherever he went, and contributing the proceeds of every such occasion to the Mount Vernon Fund. It was to him more than to any or all other persons that the ultimate accomplishment of the object was due. On the breaking out of the Rebellion, four years ago, Mr. Everett seemed to consecrate himself, and with a new earnestness, to the service of his country, and his voice, his pen, his personal influence and example, were of inestimable value to the cause of the Union. He was not spared to see the final triumph of that cause; but he lived to be gladdened by not a few of those successes which rendered the ultimate issue only a question of time. He

witnessed the rescue of East Tennessee from the Rebel forces, and forthwith devoted himself to the collection of a fund of a hundred thousand dollars for the relief of that afflicted and devastated region. He witnessed, still later, the capture of Savannah by the Federal arms, and allowed no considerations of health or of private business to prevent his uniting with his fellow-citizens at Faneuil Hall in making arrangements for sending food to her starving people. On this occasion his admirable and forcible appeal proved too much for his strength. He returned home greatly exhausted, and after a few days of suffering was struck with apoplexy on the morning of January 15th, 1865, and died without a struggle.

The highest public honors were paid to his remains. A statue of him was at once ordered by the citizens of Boston, and his memory will be cherished by scholars and by patriots to the latest generation.

Mr. Everett was elected into the Academy in 1820, being then in his twenty-sixth year. He served first as Recording and afterwards as Corresponding Secretary from 1822 to 1828 inclusive, and was its Vice-President from 1846 to 1851. In 1843 he contributed to the Transactions a "Report on the Discovery and Name of an eighth satellite of Saturn."

The Hon. JOSIAH QUINCY closed a long life, for the most part spent in public service, and honored with high distinctions, on Friday evening, July 2, 1864, at his country seat in Quincy, Mass. Born in Boston, February 4, 1772, he had nearly half completed his ninety-third year. His family history is an honorable and distinguished one through the whole period of our American annals. He was in the fifth generation of descent from his ancestor Edmund Quincy, who, with six servants, marking him as a man of consideration for the time, emigrated to Boston with the Rev. John Cotton's company in 1633, and occupied lands in Braintree, now Quincy, a portion of which have to this day remained in the possession of his descendants.

Our late associate was the only child of the honored and lamented young patriot, Josiah Quincy, Jr., who, having shown his fidelity and ability by valuable services to his country just previous to the opening of hostilities in our Revolutionary war, was lost to our cause by his death on his homeward voyage from England, April 24, 1775, at the age of thirty-one years. His son was thus left, when but three years old, to the care of the widowed mother, daughter of William Phillips, an eminent merchant of Boston. She was every way qualified for the

trust, and she devoted herself with absorbing fidelity to the oversight of the physical, moral, and intellectual training of her charge. He was sent at the age of six to the then newly established academy at Andover, and after eight years of preparation entered Harvard College in 1786, at the age of fourteen, to graduate in 1790 with the highest honors of his class. He studied law in Boston with the Hon. William Tudor, and in 1793 was admitted to the bar (and entered upon practice), though from the first it seemed as if he was intended rather for a public than a professional career. In the high party strife which marked the period of his maturity, he gave his whole-hearted devotion to the Federalists, and accredited himself through his long life to that fellowship and its succession. During a visit to New York and Philadelphia in 1795, he was presented to Washington, and made the acquaintance of the leaders of the Federal party. In 1797, he married Eliza Susan Morton of New York, living in the happiest domestic relations with her for a period of fifty-three years, which was terminated by her death in 1850. He lost his mother in 1798. He was elected a member of the State Senate in 1804, and was elected to the House of Representatives at Washington in December, 1805, having previously been unsuccessful as the Federal candidate for Congress from his District. For this latter honor he was afterwards a successful competitor with his former rival, and retained his seat by four successive elections, until 1813, when he voluntarily withdrew. His years of this service were years of intensest political excitement, his party being in a small minority, and he himself on a marked occasion having the privilege of proving his fidelity to conscience by voting in a minority of one. During the seven years following he was a member of the Massachusetts Senate, and then for two years Speaker of the House of Representatives, which office he resigned to become Judge of the Municipal Court of Boston. On the second year after Boston had received its City Charter, Mr. Quincy was chosen Mayor. He discharged his trust so faithfully, and with such unsparing hand and voice against abuses, that, after five re-elections, he was superseded. He was inaugurated as President of Harvard College, June 2, 1829, and resigned the office after Commencement in 1845, to retire to private life, but by no means to abate his activity or interest in all matters of the public welfare. His lofty and earnest patriotism in the civil war which agitated without clouding his closing years, was but the concentration of the sterling qualities which he had manifested through his whole life. He was an example of the

Roman virtues of integrity and severe rectitude, an ardent champion of universal freedom, and a stern rebuker of every form of corruption and oppression. His last years were crowned with the veneration of the community which he had served so uprightly and wisely in such a variety of ways. He added dignity to each of the numerous offices which he had filled, and won conspicuous distinctions in all of them.

Elected in the year 1803, only twenty years after the establishment of this Academy, he was for many years its senior Fellow. He filled the office of Vice-President for several years, and until near the close of his long life he manifested, by his frequent attendance at the meetings and participation in its business concerns, his lively interest in its prosperity. He may almost be called the founder of the Observatory at Cambridge. He called the elder Bond to the charge of the incipient institution, which the Academy helped to maintain, took a leading part in those measures through which the ampler endowment and equipment of the present establishment were secured, caused to be printed at his own cost the principal part of its three volumes of Annals, and continued to the last his interest and useful services in its behalf as one of its official advisers.

Mr. Quincy's most considerable literary works are, —

1. His "Memoir of Josiah Quincy, Jr.," published in the year 1825.
2. His "History of Harvard University," in two volumes, published in 1840, which passed to a second edition.
3. "Journals and Life of Major Samuel Shaw, first American Consul at Canton," issued in 1847.
4. "History of the Boston Athenæum," in 1851.
5. "The Municipal History of the Town and City of Boston during Two Centuries," 1852, written when in his eightieth year. And still later,
6. "The Life of John Quincy Adams," published in 1858.

Not to enumerate the many pamphlets which proceeded from his vigorous pen, we may mention the last, an "Essay on the Soiling of Cattle," produced in 1859, at the age of eighty-seven.

It is with no ordinary emotion that we now strike from the roll of surviving Fellows the long-honored name of one whose membership of sixty-one years dates back almost to the lifetime of our first President, Governor Bowdoin, and whose literary studies had commenced when this Academy was founded.

CAPTAIN JAMES M. GILLISS of the United States Navy, Superin-

tendent of the Naval Observatory at Washington, was born in Georgetown, in the District of Columbia, on the 6th of September, 1811. He entered the Navy in 1827, and made his first cruise in the Delaware, under the command of Captain John Downes. On returning home in 1830, he passed with honor the usual examination, and was appointed a Passed Midshipman. At that time the only instruction provided by the government for Cadets in the Navy was given on board the ships in actual service ; and this instruction depended much upon the size of the vessel and the nature of the service. Upon receiving the customary leave of absence accorded to young officers after their first voyage, he entered himself as a student in the University of Virginia, and pursued with success the course of instruction given in this institution, which had at that time among its instructors Doctors Patterson and Bonnycastle. His studies were interrupted near their close by an inflammation of the eyes occasioned by too intense application ; and receiving permission to travel, during the continuance of this malady, he visited Europe and spent several months in Paris.

His first public service on returning to the United States was in the Hydrographical Office, then recently established, and in charge of Lieutenant, now Commodore Wilkes. On the departure of that officer in command of the South Sea Expedition in 1838, it was arranged that all phenomena of use in determining longitudes, and of which the voyagers might be able to avail themselves during their progress, should be observed at Harvard College Observatory under Mr. Bond's direction, and at Washington by Lieutenant Gilliss. For this purpose a small building was erected near the Capitol, and furnished with a transit instrument which had been made for the survey of the coast. So faithfully did Lieutenant Gilliss perform his part of this service, that of the whole number of occultations visible at Washington during the absence of the expedition, only one was lost.

The building in which the observations were made, a wooden one, stood near the Capitol on a part of the same elevation. Its proximity to the halls of Congress enabled members of both branches to become familiar with one of the most important operations in astronomy, — its application to the determination of time and of geographical position. This practical exhibition of the uses of an astronomical observatory, aided by the kindly and courteous manners of the director, did much to remove the prejudice which at that time prevailed in our National Legislature against a permanent National Observatory, and to induce

Congress to entertain the project of such an establishment. In 1841 and 1842, Lieutenant Gilliss submitted plans and estimates for the construction of a permanent observatory, and in the latter year the law was passed which authorized the erection and equipment of the present Naval Observatory.

On account of the active and efficient part which Lieutenant Gilliss had taken in the furtherance of this project, he was intrusted with its execution; and in the discharge of this duty he again visited Europe. He there consulted with the most distinguished astronomers concerning the details of his plans, and contracted with the celebrated artists of that time for the necessary instruments, and on his return he superintended the erection of the building and its equipment.

In October, 1844, he surrendered the building and apparatus nearly in the state in which they have since remained to Lieutenant Maury, who had been appointed Superintendent.

Of the observations made by Lieutenant Gilliss with the Coast Survey Transit in connection with the South Sea Expedition, the most important were those for the determination of the right ascensions of the principal stars visible at Washington. The results were published in 1846, and make the first volume of published observations ever printed in this country.

From October, 1844, until April, 1861, when Lieutenant Gilliss succeeded to the superintendence of the Observatory, made vacant by the desertion of Lieutenant Maury, he was constantly employed in duties connected with the various geodetic and astronomical operations of the public service. His chief work, however, executed between 1849 and 1853, consisted in observations of the planets Venus and Mars, made at Santiago de Chile, for the purpose of obtaining a more perfect determination of the parallax of the sun. From a combination of unfavorable circumstances this work did not attain the valuable results which were anticipated. While at Santiago, Lieutenant Gilliss employed the intervals between his principal observations in executing a series of observations upon stars of the southern hemisphere.

On taking charge of the Naval Observatory in 1861, Captain Gilliss proceeded immediately to reform the character of the establishment, which, under the control of his predecessor, had lost much of its astronomical *prestige*, and become mainly a meteorological bureau. Under his supervision a new organization was given to the astronomical department. Series of observations which had been inter-

rupted or discontinued were resumed, and a new spirit was infused into the *personnel* of the establishment, which was also increased in number. Arrangements were made that the work of computation should keep pace with the observations, so that the annual volume should be ready for the press at the end of each year. This was accomplished in every year of Captain Gilliss's superintendence.

In 1863, he ordered from the celebrated artists Pistor and Martins of Berlin a Meridian Circle of larger dimensions than any now in this country. The details of its construction, and the preparations for its proper reception and mounting, were matters of much solicitude to him. Indeed, these were the subjects which most occupied his thoughts at the time his career was so suddenly brought to a close.

He died on the morning of the 9th of February, almost in the act of waking from an undisturbed slumber, without any previous illness or indisposition, and apparently without pain. The previous day had been one of unusual happiness to him, — his eldest son, a captain of artillery, who had been a prisoner since October in the hands of the Rebels, having just been exchanged and restored to him.

We now turn our thoughts to one whose prolonged labors as a teacher and cultivator of science claim our grateful recognition, and whose services as the founder and conductor of the most widely known and valued of American scientific journals entitle him to a distinguished place among the promoters of science in this country.

BENJAMIN SILLIMAN was born in North Stratford (now Trumbull), Connecticut, August 8, 1779, of a family which has resided in Fairfield, in that State, since the early colonial days, and which is believed to have come originally to this country from Switzerland. His father, Gold Selleck Silliman, a distinguished lawyer of Fairfield, held during the Revolutionary war the office of Brigadier-General of the State militia, was intrusted with the protection of the Long Island coast, commanded the troops that were gathered in 1777 for the defence of Danbury, and three years after was taken prisoner, and for several months held in captivity.

The subject of our notice, the younger of the two sons of General Silliman, entered Yale College at thirteen, and graduated at the early age of seventeen. Three years later he was called to a tutorship in the College, and, devoting his leisure to the study of law, he was in 1802 admitted to the bar.

At this critical moment, fortunately for the interests of the College

and of science, a more congenial field of labor presented itself to the young college tutor in the rapidly expanding domain of Chemistry; and we can imagine how readily he consented, at the solicitation of Dr. Dwight, the President of Yale, to renounce his proposed profession and to accept the chair of Chemistry, then for the first time established in the College.

To prepare himself for this position he spent some time under the instruction of Dr. Woodhouse, the celebrated Professor of Chemistry in the University of Pennsylvania, and in 1805 made a visit to Europe; in the course of which he attended the lectures of eminent professors in London and Edinburgh, travelled over the mining districts of England, and gathered for the College books, apparatus, and other facilities for illustrating chemical and physical science.

Returning thus equipped, he resumed the duties of the chair in which he had already made a beginning, and entered upon that career as a college teacher and public lecturer, in which his ready and impressive elocution and his attractive presence, as well as the clearness and value of his instructions, soon won the interest of his pupils, and in later years marked him as a popular expounder of science.

In the College lecture-room and laboratory his genial enthusiasm kindled a taste for experimental and natural science, and gathered around him many eager spirits whose scientific labors have in later years given proof of the value of his hearty, enthusiastic teaching.

For some years Professor Silliman's instructions were confined to the department of Chemistry, in which his tact in manipulation was scarcely more remarkable than the delight with which, it is said, he seemed to enjoy his own experiments, as if, like the class, he had never before witnessed them. After a time, he added to the course on Chemistry one on Mineralogy and another on Geology, in both of which he soon surrounded himself with earnest students, of whom not a few in after years became known as diligent collectors or as scientific explorers.

The inspiring influence which Professor Silliman exerted as a college teacher shines forth in the fact that so many of the minds which he aroused to the study of nature have been successful investigators and teachers in different portions of the country, and that all his pupils, whether devoted to science or letters, bear testimony to the interest which he awakened in their pursuits.

Nor was it simply his enkindling influence as an instructor that

wrought these results. The kindness and sympathy with which he was accustomed to counsel and help his students he extended to all who were laboring to advance knowledge, cheering them in their studies and in their efforts at original investigation with a generous appreciation no less honorable to him than it was helpful to the rising science of the country.

In estimating Professor Silliman's services as a teacher of science, we should remember that he began his labors when Chemistry was in its infancy, and Geology was but emerging from a chaos of conjectural cosmogonies. When he entered upon his task, he was unprovided with apparatus or specimens, "with scarcely a retort, and only minerals enough to fill a candle-box."

With the intrepidity of a pioneer he set himself to his work, and such was his success in it, that, at the close of the fifty years of almost unbroken service as a college professor, he could not only point to a long array of chemists and geologists whom either directly or indirectly he had helped to train, but to superb collections of minerals and fossils and other materials of instruction gathered for his College mainly through the influence of his enthusiasm and personal popularity.

The characteristics which marked his college lectures were even more conspicuously shown when Professor Silliman was called on to discourse on scientific subjects before a general audience. His brilliant experiments and other illustrations, and the rhetorical attractions of his style, made him one of the most welcome of popular lecturers on Chemistry and Geology, and secured him a large attendance on the courses of lectures which he gave in many of the principal towns of the United States, from Boston as far west and south as St. Louis, New Orleans, and Mobile.

Important as were Professor Silliman's services as a college teacher and officer and as a popular lecturer, his strongest claim to the gratitude of men of science, especially in this country, rests upon the establishment and the maintenance, often under very discouraging circumstances, of the American Journal of Science, better known both in Europe and this country as Silliman's Journal, with which his name continued to be connected until his death, and of which for twenty years he was sole, and for eight years more senior editor.

Founded in 1818 as a quarterly, but for many years past published as a bi-monthly periodical, this journal has for a period of forty-seven years been the leading exponent of the investigations and discoveries

of the science of this country. The comprehensive plan set forth in the Prospectus by which the Journal was first heralded marks the sagacious foresight of its author. Sustained for so many years by his untiring perseverance and unfailing hope, and in later times by the editorial ability of his coadjutors and successors, it has held its position as a chosen repository of American scientific thought and activity, and as the faithful exponent of scientific progress in other countries.

Of the services of this journal to American science it is not too much to say, that, more than any other similar publication, it has aided and stimulated our countrymen in their scientific labors, and has made their names and works familiar to men of science abroad, while through the variety and weight of its contributions it has not only won a high reputation among contemporary journals, but has vindicated for our country an honorable place among the communities in which science is most promoted and esteemed.

To have been instrumental towards such results is certainly no slight distinction, and when we remember that the Journal was maintained from the beginning at the pecuniary risk of its founder, and that its publication has been for the most part a financial burden to him, we feel that the generous devotion to science which led him to persevere, in spite of these discouragements, entitles him to our lasting gratitude.

With such various and engrossing labors as teacher, editor, lecturer, and in other modes of helpful activity, it was not to be expected that Professor Silliman could devote much time to original scientific investigation, and perhaps his peculiar gifts of temperament and intellect were such as to find their most useful application in the wider and more social sphere of effort in which they were so earnestly employed.

He however found time to make a number of original experiments and observations, among which may be specially noted the application of the newly invented blowpipe of his friend, Dr. Hare, to the fusion of a variety of bodies which were before regarded as infusible, the discovery of the transference of the particles of carbon from the positive to the negative pole of the galvanic apparatus, and the fusion of the carbon in the voltaic arc; the two last-named facts, though long disputed in Europe, being now generally recognized.

In the field of scientific literature, Professor Silliman's labors, apart from his contributions to the Journal, consist of a Text-Book on Chemistry, in two octavo volumes, which appeared in 1830, and the Notes and Appendices which he added to Bakewell's Geology, republished

about the same time, and of which three editions were issued in the course of ten years.

Of Professor Silliman's other publications the most noteworthy are the "Journal of Travels in England, Holland, and Scotland," which appeared in 1810, embodying his observations during the early tour of scientific preparation before referred to, and the narrative of his second "Visit to Europe," published in 1853, both of which, by their genial spirit and literary graces, as well as by the interest of their local, personal, and scientific details, won the favor of readers on both sides of the Atlantic.

It was in the latter of these years that our associate, now venerable from his age as from his labors, resigned his Professorship in the College; but he continued for two years more to discharge the duties of of the chair of Chemistry and Geology, and had thus the rare distinction of extending to half a century a career of active college service.

His remaining years, passed in retirement from academic, and for the most part from scientific labors, showed no abatement of interest in the progress of science and in the promotion of enterprises tending to the moral and material welfare of his fellow-citizens.

The kindness of his nature, growing even more tender as age advanced, combined with a simple, hopeful piety to shed a lustre on the evening of his happy and honorable life.

Taking a warm interest in all great public affairs, he continued to the last to watch the growth of that national life of which in childhood he had witnessed the commencement. Moved by the wrongs of the oppressed, and indignant at the attempt to perpetuate injustice by the overthrow of our government, our venerable colleague came forward at the outbreak of the Rebellion, with all his youthful ardor and the influence of his years and reputation, to second his fellow-citizens in re-establishing the national unity on the basis of equal justice and Christian humanity and truth.

It is a touching proof of his zeal in all that related to the welfare of our soldiers and the success of our cause, that the last public meeting he attended was a service held in behalf of the Sanitary Commission, and that the indisposition which resulted in his death was probably the immediate consequence of his exposure at that time.

Ten days after this, on the morning of November 24, 1864, the day set apart by President Lincoln for a national thanksgiving, while yet the words of patriotism, pious worship, and tender endearment were upon his lips, he passed away.

Thus, at the advanced age of eighty-five, peacefully and beautifully closed the life of one whose labors in behalf of education, science, and social advancement have been inwoven in the history of more than two generations, and will long cause his name to be honored and gratefully remembered.

Last year five distinguished names disappeared from our list of foreign honorary members. During the year now closed we have lost only one.

FRIEDRICH GEORG WILHELM STRUVE, one of the great astronomers of the age, died at Pulcova on the 23d of November last. He was born at Altona in 1793, and was the son of Jacob Struve, a scholar of high reputation, especially as a philologist. He emigrated to Russia at the age of fifteen, and was educated at the University of Dorpat, where he became Professor of Astronomy at the early age of twenty, and began at once his astronomical observations. These were continued, with few interruptions (caused mostly by geodetical work and scientific journeys), until the year 1839, when he was called to the charge of the Imperial Observatory at Pulcova, an institution in some respects the first in the world. He retained the directorship of this celebrated establishment until the year 1861, when, under the weight of advancing years and infirmities, he resigned it to his son, at the close of a half-century of labors of great importance to science and to his adopted country.

In the first place, Struve had no superior among his compeers as an astronomical observer. Even Bessel must yield to him the palm for nicety of work in detail, while in Struve's early volumes of observations the influence of Bessel's great mind is plainly seen. The first three volumes of the "*Observationes Dorpatenses*" are chiefly occupied with those made with Dollond's transit instrument, and, partly unreduced as they are, they are still indispensable in all researches relating to stars near the pole. Struve's remaining observations at Dorpat are brought into the shape of fully discussed results in his two great works, "*Stellarum Duplicium Mensuræ Micrometricæ*," and "*Stellarum Fixarum imprimis Duplicium et Multiplicium Positiones Mediæ*." These almost exhaust the subject of double stars for the years about 1830, and are of the highest historical importance for future astronomy.

The Pulcova observations, of which about fifty thousand have been made by the meridian instruments alone, are now in process of publication. It has been thought well that their results should appear to-

gether as a whole, and it is expected that they will put a new face upon many astronomical subjects. Many detached papers have appeared, however, which embody the results of completed investigations.

The geography of Russia, on the other hand, owes very much to Struve. The measurement of the arc of the meridian, of $25^{\circ} 20'$ in length, between Fuglenaes on the Arctic coast and Ismail on the Danube (the largest yet completed, and which may at some future time be prolonged as far south as Constantinople, or even to Crete), was in great part his work, although the names of Jenner, Selander, and Hansteen appear with his on the title-page.

But the chief peculiarity of Russian geography is, that it is founded largely upon astronomical determinations, these taking the place of triangulation in that extensive country. It has been found possible in this way to survey large districts with great expedition, yet in a thorough manner. But for this two things are indispensable, — portable instruments which possess great delicacy, and a corps of observers trained in all the refinements of modern astronomy. Struve incited the makers of such instruments to turn their powers in this direction, while he stimulated their ambition by establishing a workshop at Pulcova to compete with them; and the Repsold vertical circles and the Munich theodolites of small dimensions are now the admiration of astronomers. And Dorpat and Pulcova were the best possible training schools for the young astronomers who were to use these instruments.

It is an interesting fact to us, that the first determination of the longitude of San Francisco, which was within ten miles of the truth, was calculated under Struve's direction, from observations made by his pupil, Preuss.

In fine, it may fairly be said that Russia has done more for her own geography than any other country, and that Struve has been more effective in this work than any other Russian. Without prejudice to his astronomical reputation, it may be concluded, that what Bessel was to proper astronomy Struve was to astronomical geography.

Struve was no recluse, but he enjoyed society in a high degree. To his personal friendship with the Emperor and with the leading statesmen of the time is owing much of the liberality with which his various scientific undertakings were supplied. Those who have visited the astronomical colony at Pulcova have invariably returned charmed by the genial hospitality of the head of the establishment, — a hospitality most freely dispensed to all who had in any degree claims upon it, and which

made the great Observatory a delightful home for the time to those who came from foreign lands.

The elections into the ranks of the Academy during the past year have been unusually few ; consisting of two Resident Fellows, of whom one is placed in Class II. Section 3, one in Class II. Section 4. Three Foreign Honorary Members, all in Class I., are placed severally in Sections 1, 2, and 3 of that Class.

One of the members (Professor H. D. Rogers of Glasgow) has been transferred from the list of Resident to that of Associate Fellows, in Class II. Section 1.

In conclusion, the Council submitted a nomination to fill the vacancy in the list of Foreign Honorary Members made by the decease of M. Struve ; also a nomination to the list of Associate Fellows.

Professor Lovering, as Chairman of the Committee of Publication, presented the report of the committee, accounting for expenditures in printing the Memoirs and Proceedings under the appropriations of the past year.

Dr. A. A. Gould, as Chairman of the Library Committee, presented the Annual Report on the condition of the Library.

The Annual Report of the Treasurer, attested by the Auditors, was read, accepted, and ordered to be entered on the records.

The following appropriations were made for the ensuing year : —

For General Expenses	\$1,200.00
For the Library	700.00
For Publications	800.00

The following report of the Rumford Committee was accepted, and the vote recommended was passed : —

Whereas, Prof. Daniel Treadwell, of Cambridge, Massachusetts, between the years 1840 and 1845, did devise, execute, and publish certain improvements in the management of heat, by which guns of great strength and endurance were constructed, — especially by the coiling of iron in the direction of its greatest tenacity, and welding the coils by means of moulds and mandrils and hydraulic pressure

into a hollow cylinder ; whereby a system of construction, before used in small-arms only, was rendered applicable to guns of any calibre, and which is now generally adopted in the manufacture of large cannon ; therefore, the Rumford Committee recommend to the American Academy of Arts and Sciences that the following vote be passed : —

Voted, That the Rumford Premium be awarded to Professor Daniel Treadwell, for improvements in the management of heat, embodied in his investigations and inventions relating to the construction of cannon of large calibre, and of great strength and endurance.

The following gentlemen were elected members of the Academy.

To be Resident Fellows : —

Dr. John E. Tyler,	in Class II. Section 4,
Dr. Edward H. Clark,	“ “ II. “ 4,
Rev. Edward Everett Hale,	“ “ III. “ 3,
Mr. George Bemis,	“ “ III. “ 1,
Hon. Charles Sumner,	“ “ III. “ 3.

To be Associate Fellows : —

Mr. F. B. Meek, of Washington,	in Class II. Section 1,
Dr. John W. Draper, of New York,	“ “ I. “ 3,
Dr. Tayler Lewis, of Union College,	“ “ III. “ 1,
Dr. S. Weir Mitchell, of Philadelphia,	“ “ II. “ 3,
Prof. Samuel G. Brown, of Dartmouth Coll.,	“ III. “ 3,
Rev. Dr. Daniel R. Goodwin, of Philadelphia,	“ III. “ 1.

Nominations for election into the Academy were presented and read.

The annual election resulted in the choice of the following officers for the ensuing year.

ASA GRAY, *President*.

CHARLES BECK, *Vice-President*.

WILLIAM B. ROGERS, *Corresponding Secretary*.

CHAUNCEY WRIGHT, *Recording Secretary*.

GEORGE LIVERMORE, *Treasurer*.

JOSIAH P. COOKE, *Librarian*.

Council.

THOMAS HILL,	} of Class I.
JOSEPH LOVERING,	
JOHN B. HENCK,	
AUGUSTUS A. GOULD,	} of Class II.
LOUIS AGASSIZ,	
JEFFRIES WYMAN,	
ROBERT C. WINTHROP,	} of Class III.
GEORGE E. ELLIS,	
ANDREW P. PEABODY,	

Rumford Committee.

JOSEPH LOVERING,	JOSEPH WINLOCK,
MORRILL WYMAN,	WOLCOTT GIBBS,
WILLIAM B. ROGERS,	CYRUS M. WARREN,
FRANK H. STORER.	

Committee of Finance.

ASA GRAY,	} <i>ex officio</i> , by statute.
GEORGE LIVERMORE,	

No ballot was taken for the third member of this Committee.
The other Standing Committees were appointed on the nomination of the President, as follows:—

Committee of Publication.

JOSEPH LOVERING,	JEFFRIES WYMAN,
CHARLES BECK.	

Committee on the Library.

AUGUSTUS A. GOULD,	CHARLES PICKERING,
JOHN B. HENCK.	

Committee to audit the Treasurer's Accounts.

THOMAS T. BOUVÉ,	CHARLES E. WARE.
------------------	------------------

Professor Gray presented the following paper : —

Characters of some New Plants of California and Nevada, chiefly from the Collections of Professor William H. Brewer, Botanist of the State Geological Survey of California, and of Dr. Charles L. Anderson, with revisions of certain Genera or Groups. By ASA GRAY.

The diagnoses of two or three of the following species, of the collections of 1860–1862, have already been published in the Proceedings of the California Academy of Natural Sciences, Vol. 3, pp. 101–103. The plants described are from the collections of the Geological Survey when not otherwise specified.

ARABIS (LOMASPORA) PLATYSPERMA: humilis e basi suffrutescente; foliis cum caule pube stellata canescentibus spatulatis integerrimis, summis oblongis arcte sessilibus obtusis; racemo paucifloro; (petalis roseis;) siliquis arrectis rectisque lato-linearibus ($1\frac{1}{2}$ – $2\frac{1}{2}$ poll. longis, lin. $2\frac{1}{2}$ latis) acuminatis planis, valvis laxe reticulatis; stigmatibus sessilibus; seminibus amplissime alatis. — Sierra Nevada, on Mount Dana, alt. 13,227 feet, and above Ebbett's Pass.

STREPTANTHUS POLYGALIOIDES: *Eucilsia*, *Dipteroclæna*, glaber, paniculato-ramosus; foliis filiformibus integerrimis, nonnullis basi subamplexante sagittatis; racemis spiciformibus; calyce luteo petala purpurascens subæquante, sepalis duo exterioribus maxime dilatatis subcordato-rotundatis, interioribus oblongo-lanceolatis acuminatis; siliquis (immaturo) angustissime linearibus stylo brevi apiculatis. — On very dry hillsides, in serpentine soil, along the Tuolumne River. A remarkable species, with the petals, &c., of the *Eucilsia* section, but, on account of its peculiar calyx, rather to be distinguished as of a separate section. The light-yellow and apparently scarious petaloid sepals are of two very different shapes; the inner pair nearly as in other species of the genus; but the outer much dilated, apparently nearly flat, and not unlike the wings of some species of *Polygala*, about 3 lines in length and breadth, and as it were enclosing the rest of the flower; the tips of the purplish or white and purple petals, and the oblong-sagittate blunt anthers barely exerted. A pair of the filaments frequently connate. The plant is probably an annual.

STREPTANTHUS PROCERUS, Brewer. *S. flavescens*, Gray, in Proceed. Amer. Acad. 6, p. 186, as to the "very large or luxuriant form

gathered at the coal-mine near Monte Diablo by Dr. Brewer." This is doubtless a truly distinct species, growing six or seven feet high in alluvial soil, the greenish-white flowers fully half an inch long, the stem glabrous and glaucous.

THELYPODIUM (**PACHYPODIUM**, Nutt.) **BRACHYCARPUM**, Torr. (in Wilkes's S. Pacif. Ex. Exped. Bot. W. Amer. t. 1); caule virgato; foliis caulinis parvis crebriusculis sagittatis integerrimis erectis; racemo elongato angustissimo spiciformi; pedicellis calyce brevioribus; sepalis linearibus; petalis angustissime linearibus; antheris mucronatis; siliquis semi- aut sub-pollicaribus, valvis carinato-uninerviis. — Valley of Mono Lake, alt. 6,500 feet. This well-marked species having been rediscovered by Prof. Brewer, a diagnosis is here given, since that of Dr. Torrey is still unpublished, and the plate is little known. Dr. C. L. Anderson has collected it in Nevada, with a very long virgate spike, and with some mature fruit.

SMELOWSKIA? **CALIFORNICA**: cinereo-puberula, glabrata; radice ut videtur annua vel bienni; caule 1–2-pedali; racemis demum paniculatis; foliis pinnatipartitis, segmentis 5–7 oblongis obtusis sæpe 3–5-lobatis; floribus parvis luteis; calyce deciduo; siliculis pusillis ellipticis oblongisve utrinque acutis stylo brevissimo apiculatis, loculis 1–2-spermis. — On Mount Dana, alt. 10,000 feet, June, in flower; and near Mono Lake, alt. 6,450, July, with young fruit. — With its annual or biennial root, and much the habit of *Sisymbrium canescens*, this would render the genus *Smelowskia* yet less natural; but here it technically belongs. The flowers are only a line long; the elliptical, ovoid, or somewhat fusiform silicles one or two lines long; valves very obscurely one-nerved; cells 2-ovulate. Young seeds oblong.

DRABA EURYCARPA: multiceps, nana, stellato-tomentosa; foliis spathulatis integerrimis in caudice rosulato-confertis; scapo leviter exserto paucifloro; siliquis ovatis stylo subulato acuminatis glabris ($\frac{1}{2}$ – $\frac{3}{4}$ -pollicaribus). — On a peak of the Sierra Nevada south of Sonora Pass, alt. 11,500 feet. In fruit only, the seeds and most of the valves shed. The tufts of leaves (half an inch in length) rise only about an inch above the surface of the ground, and above them the large and silvery partitions of the pods are very conspicuous. Funiculi short, about 10 in each cell.

CLEOMELLA PARVIFLORA: tenuis, diffusa; foliolis cum bracteis simplicibus linearibus; floribus parvis; pedicellis filiformibus elongatis;

capsula obovato-globosa, stipite (vix calycem superante) styloque brevissimis; seminibus lævibus. — Nevada, near Carson City, Dr. C. L. Anderson. The foliage nearly as in *C. tenuifolia*, but a more delicate plant, only about a span high, the flowers and pods only half the size, and the stipe much shorter than in any other species, not half a line in length. Dr. Anderson also sends *C. longipes*, Torr., from Nevada.

LINUM § HESPEROLINON. Spec. 3 Californicæ, annuæ, trigynæ, capsulis 6-locellatis; unguibus petalorum basi tri-appendiculatis. Styli a basi liberi, stigmatibus parvis. Dentes inter stamina nulli. Sepala ovato-lanceolata, herbacea, immarginata, vix uninervia. Flores brevipedicellati. Folia angustissime linearia, subfiliformia, plerumque alternata. Caulis inferne simplex, strictus.

LINUM CALIFORNICUM (Benth., Pl. Hartw. p. 299): glabrum; caule superne in cymam effusam repetito-dichotomam soluto; glandulis stipularibus geminis; sepalis margine subglandulosis; petalis albis roseisve. — Dr. Torrey, in Bot. Mex. Boundary, first noticed the trigynous character, which it shares with the following new Californian species. All three exhibit three little teeth or auricles at the base of the claw of the petals, one on each margin and one adnate to its inner face. The coincidence of these characters invalidates the technical distinction of the genus *Reinwardtia*, — in which, however, the teeth or appendages of the petals according to Planchon (in Lond. Jour. Bot. 7, p. 522), or two of the three according to Bentham and Hooker (Gen. Pl. p. 243), are dorsal.

LINUM CONGESTUM: glandulis stipularibus inconspicuis; caule foliisque fere glabris; floribus in ramis brevibus suberectis capitato-glomeratis; sepalis pubescentibus eglandulosis; petalis roseo-purpureis; stigmatibus brevibus vix incrassatis. — Marin County, coll. H. N. Boler. Flowers about the size of those of *L. Californicum*.

LINUM BREWERI (Gray in Proceed. Calif. Acad. l. c.); glabrum; caule exili apice confertim paucifloro; foliis raro oppositis; glandulis stipularibus conspicuis; sepalis margine glandulosis; petalis aureis; stigmatibus acutis. — Dry hills of the Monte Diablo range. Plant only a span high, in flower; the fruit not seen.

There might seem to be a fourth species of the group, *L. trisepalum*, of Kellogg, in Proceed. Acad. Calif. 3, p. 42, fig. 10. But his plant is *Helianthemum scoparium*, Nutt.! And his *L. decurrens* is evidently *L. perenne*.

LUPINUS MEIONANTHUS: undique sericeo-incanus; caulibus ut videtur herbaceis vel suffruticosis adscendentibus e radice perenni; foliolis 6–9 concoloribus oblanceolatis obtusis; stipulis parvis setaceis; bracteis calyce brevioribus; floribus minimis (vix lineas 3 longis) verticillatis in racemum spiciformem congestis; calyce pedicello longiori ebracteolato, labiis fere integris corollam glabram subæquantibus; carina apice brevi lato obtuso inflexa ciliata; leguminibus ovatis incanis 1–2-spermis. — Nevada, near Carson City, Dr. C. L. Anderson. It would be unsafe to describe a new Lupine before the old species are settled, except in a case like this, — a silvery-canescient species with remarkably small flowers. These are blue or purple, with a yellow spot on the vexillum. Leaflets 6 to 11 lines long, mostly equalling the petiole. Legumes half an inch long. Seed with a small hilum.

TRIFOLIUM ANDERSONII: (§ *Lupinaster*) undique albido-villosissimum, cæspitoso-depressum; caudicibus crassis lignescentibus stipulis majusculis scariosis vestitis; foliolis 4–6 oblongo- seu obovato-cuneatis mucronatis integerrimis; pedunculis folia adæquantibus; capitulo globoso multifloro; floribus sessilibus; dentibus calycis tubo campanulato sublongioribus subulato-setaceis; corolla roseo-purpurea haud scariosa. — Mountains of Nevada, near Carson City, Dr. C. L. Anderson (1862 and 1864). A most peculiar species, forming tufts a few inches in height, at first nearly acaulescent, but the stout caudices or stems sometimes attaining the length of five or six inches, and ascending or decumbent, leafy, beset, as is the whole plant, with very soft silky-villous hairs; the calyx, &c., very densely so. Petioles and peduncles $1\frac{1}{2}$ to 2 inches long. Leaflets half an inch in length. Head very compact, with an alveolate-squarrose receptacle, the outermost very short bracts forming a vestige of an involucre. Flowers half an inch long; the corolla apparently pink, with paler wings and keel, these adnate by their claws to the tube of filaments. Ovary tomentose, scarcely stipitate: ovules about 5. Legume globular, 1–2-seeded.

TRIFOLIUM BIFIDUM (Gray in Proceed. Acad. Calif. supra cit.): villosiusculum seu glabellum; caulibus e radice exili (annua?) diffusis gracilibus; stipulis ovato-lanceolatis setaceo-acuminatis integris; foliolis lineari-cuneatis lateribus rariter dentatis apice bifidis vel excisis mucrone interjecto; pedunculis folia bis terve excedentibus; capitulo nudo 6–12-floro; floribus pedicellatis demum reflexis; calycis 5-partiti dentibus subulato-setaceis parce hirsutis corollam roseam scarioso-per-

sistentem subæquantibus. — In a ravine between Monte Diablo and the San Joaquin. Heads about the size of those of the small form of *T. gracilentum*, to which species this is allied.

TRIFOLIUM MONANTHUM: *Involucraria*, pygmæum, parce villosulum, e radice exili (annua?) ramosum; stipulis ovato-lanceolatis subfoliaceis integerrimis 3–5-nervatis cuspidato-acuminatis; foliolis obovato-cuneatis nunc retusis mucronato-dentatis; pedunculo folium haud superante; involucre unifloro (rarius bifloro) fere diphylo calyce cylindraceo dimidio brevior; corolla albo-purpurascens elongata. — Moist bank by Soda Springs, Tuolumne River, alt. 8,700 feet. A very distinct little species, only about an inch high, the stems or branches terminated by a peduncle of 3 to 9 lines in length. Leaflets 2 or 3 lines long. Corolla half an inch long, twice or thrice the length of the calyx (the teeth of which are broadly lanceolate, spinulose-pointed, and shorter than the tube), somewhat glandular on the elongated tube, not scarious or inflated after flowering. Legume stipitate, two-seeded. Leaves of the involucre mostly two-cleft.

TRIFOLIUM AMPLECTENS, Torr. & Gray, occasionally white-flowered, instead of a nearly sessile 4–6-seeded legume, as in the specimens of Douglas, has it stipitate and with only one or two large seeds (indeed with the ovary biovulate) in those of Coulter, Bigelow, and Brewer. Generally there is a central pedicellate flower, under which is a minute truncate involucre, like the involucre of the following plant; sometimes indeed this involucre is two-flowered, showing a tendency in the head to become proliferous.

TRIFOLIUM DEPAUPERATUM, Desv. (*T. stenophyllum*, Nutt. Pl. Gamb. p. 151?), now identified in California, adds another to the Clovers common to that country and to Chili. Dr. Brewer collected two forms on successive days (April 18 and 19) in the vicinity of Sonoma. One, which is slender and erect from an annual root, well accords with specimens of Gay's *Flora Chilena*, except that the flowers are rather larger and a few more in the head; and the leaflets are longer and narrower; while Fremont gathered (in 1845, no. 235) the exact counterpart of the Chilian plant. Dr. Brewer's other form is more tufted and decumbent, the root as if perennial. The involucre in *T. depauperatum* is minute and truncate, or reduced to a mere scarious ring. The central flower is commonly pedicellate and with an obsolete involucre, just as in *T. amplexans*, and the calyx, corolla, &c., so accord with that spe-

cies, that, although the differences are constant so far as yet observed, it may confidently be inferred that one has been derived from the other.

In *T. microcephalum*, Pursh, well-developed heads show a receptacle bearing the flowers in three verticils.

ASTRAGALUS LENTIGINOSUS (Dougl., Gray, Rev. Astrag., p. 194), var. **FLORIBUNDUS**: subglaber; caulibus productionibus (pedalibus) adscendentibus e pleris axillis floriferis; pedunculis breviusculis spicatulifloris; floribus albis nunc apice purpureo tinctis; leguminibus junioribus rectis acutissime acuminatis glabris. — Nevada, near Carson City, Dr. C. L. Anderson. Flowers and legumes considerably smaller than those of the nearly allied *A. diphysus*, the teeth of the cylindrical calyx shorter. The mature legumes in one specimen are somewhat mottled.

ASTRAGALUS ANDERSONII: undique pube mollissima subvillosa canescens; caulibus e radice perenni adsurgentibus (pedalibus) foliosis; stipulis discretis triangulari-lanceolatis; foliolis 7–12-jugis ovalibus oblongisve rarius obovatis; pedunculis folium superantibus; spica cylindrica vel oblonga densius multiflora; calycis dentibus setaceis tubo campanulato subæquilongo corolla cærulescente dimidio breviori; legumine oblongo-lineari (semi-sub-pollicari) chartaceo-coriaceo tomentuloso arcuatim incurvo subcompresso dorso sulcato septo ad suturam ventralem intruso bilocellato 12–20-spermo. — Near Carson City, Nevada, Dr. C. L. Anderson (1863 and 1864). A soft-downy and hoary species, not particularly related to any other North American species known to me, but with much the aspect of *A. chatodon* Torr.,* of the same region farther north. Leaflets 3 or 4 lines long. Flowers of about the same length, usually crowded in a spike of one or two inches in length (in fruit from 2 to 6 inches; the pedicels very short. Bracts setaceous, equalling the calyx tube. Corolla apparently ochroleucous tinged with blue or purple, becoming white or yellowish. Flowers more or less deflexed after anthesis. So are the pods, which curve upwards or are almost hamate when fully ripe. They are not at all stipitate. Seeds small.

* Vide Gray, Rev. Astrag. p. 194. The specific name *chatodon* being preoccupied by Bunge, this may be named, in honor of the discoverer, the Rev. Mr. Spalding, *A. Spaldingii*.

ASTRAGALUS CYRTOIDES, Gray, Rev. Astrag., p. 201 ; forma magis pubescens ; foliolis sæpius obovatis vel obcordatis, cum fructu ; — nempe, legumine cartilagineo dorso haud intruso prorsus uniloculari sublineari utrinque acutato tereti e stipite pendente calycem longe superante sursum curvato hami-vel falciformi nunc demum annulari, suturis marginantibus angustis, ventrali acutissima. — Nevada, near Carson City, Dr. C. L. Anderson, who collected flowering specimens in 1863, and mature fruit in 1864, which enables me now to complete the account of this species. The fruit will be seen to accord with the *Podo-sclerocarpi*, but the habit and structure of the flowers show the nearest affinity with *A. racemosus*, Pursh, with which the species was associated in my revision of our *Astragali*. The legume is an inch or more in length, on a stipe nearly half an inch long ; it is of a very firm cartilaginous texture, tomentulose, curved in the form of a pruning-hook or sickle, or at length even into a complete ring, the nerviform replum in old pods separable, that on the ventral side forming a narrow acute margin or edge.

ASTRAGALUS TENER, Gray, l. c., p. 206 : forma foliis fere linearibus raro emarginatis ; floribus læte violaceis. — Oakland, coll. Wm. Holder. Immature legumes more or less reflexed, half an inch long, lanceolate-linear, silky-puberulent, on a very short stipe which is hidden in the tube of the calyx, several-seeded, 2-locellate, the transverse section obcordate, the partition reaching to the ventral suture.

ASTRAGALUS INEPTUS: (*Oroboidei*?) cinereo-pubescens ; caulibus e radice perenni diffusis ramosis (spithamæis et ultra) ; stipulis scariosis discretis ; foliolis 6–9-jugis oblongis emarginatis supra fere glabris ; racemis oblongis densifloris brevi-pedunculatis folio brevioribus ; corolla alba vel ochroleuca apice pupurascente, ala rectiuscula ; legumine immaturo ovato acuminato subincurvo puberulo membranaceo inflato haud stipitato polyspermo septo intruso fere bilocellato. — Dry, rocky mountain near Sonora Pass, alt. 9,000 feet. — A low, homely species, of which mature fruit is still a desideratum. The root apparently perennial. Leaflets 4 to 6 lines long, slightly fleshy, grayish underneath with a fine lax pubescence. Flowers half an inch long, on very short pedicels, narrow, the tips of the narrow wings and sometimes of the short keel tinged with purple. One or two forming legumes occur ; they are scarcely above half an inch in length, thin-walled, and evidently inflated at maturity, moderately grooved at the dorsal suture,

the thin septum extending so as nearly or quite to touch the ventral suture.

ASTRAGALUS WHITNEYI: (*Inflati*,) striguloso-puberulus; caulibus e radice perenni conferte ramosis spithamæis; stipulis brevibus adversus petiolum connatis; foliolis 5-9-jugis lineari-oblongis; pedunculis folium adæquantibus subcapitato-plurifloris; calycis dentibus triangulatis tubo campanulato quadruplo brevioribus; corolla læte purpurea, carina falcato-incurva alas adæquante vexillo paullo brevior; legumine pendente glaberrimo (maculoso) vesicario ovali subpollicari apice obtusissimo basi in stipitem e calyce leviter exsertem attenuato. — On the same mountain with the preceding species, in loose soil, near the summit, alt. 10,000 feet. — This species, which may appropriately bear the name of the distinguished Director of the California Geological Survey, would appear to be a near relative of the incompletely known *A. Hookerianus*, Gray, *Astrag.*, l. c., p. 215; but the pubescence is strigulose, the stipules conereted and not scarious, and the pods very much smaller and glabrous. The young pods on the flowering specimens are not quite an inch long (including the short stipe): a loose one which seems as if full grown is not larger, and is mottled with purple. The flowers are half an inch long, and apparently blue or purple; in Dr. Brewer's notes upon the fresh plant, they are said to be "bright red-violet."

ASTRAGALUS PLATYTROPIS: multiceps e rhizomatibus elongatis, nanus, vix caulescens, sericeo-argentatus; foliolis 3-5-jugis obovatis; pedunculis scapiformibus folium adæquantibus apice capitato-paucifloris; calycis dentibus subulatis tubo campanulato paullo brevioribus; corollæ (albæ seu lutescentis apice purpuratæ), carina dilatata recta apice hinc rotundata alas vexilloque æquilonga; legumine globoso-ovato membranaceo vesicario-inflato (vix pollicari) estipitato cinereo-puberulo polyspermo bilocellato, septo versus medium seminifero. — With the preceding species, in loose gravel and sand near the summit (alt. 10,000 feet). — Leaves and flowering stems or scapes rising only two or three inches above the soil. Stipules triangular or ovate, canescent. Leaflets 3 or 4 lines long. Flowers 5 or 6 in a small head, barely 4 lines in length; the broad keel tipped with purple; the rest of the corolla apparently white or yellowish. Forming legumes canescent, when older glabrate, scarcely grooved at the sutures; both sutures are septiferous, the funiculi being adnate to the ventral portion of the sep-

tum, in the manner of the *Diphysi*, — to which this remarkable species would belong by its fruit; but its habit is of the *Lotiflori*, and the short wings and standard are peculiar.

ASTRAGALUS PYCNOSTACHIUS: caule valido foliisque pube molli canescentibus; stipulis scariosis discretis; foliolis multijugis oblongis apice obtuso vel retuso mucronatis; pedunculis folium æquantibus; spicis etiam fructiferis densissimis oblongis vel cylindræis; calycis pubescentis dentibus subulatis tubo brevi-campanulato brevioribus; corolla ut videtur pallida; leguminibus ovatis coriaceis glabris turgide lentiformibus stylo cuspidatis haud stipitatis calycem 2–3-plo excedentibus in spicam retrorsum congestis 1–3-spermis (ovulis 5), sutura neutra intrusa. — Baulinas Bay, in salt marshes within reach of tide, H. N. Bolander. — I have not seen the base of the stem: it must be more than a foot high, and rather stout. Leaflets 3 to 6 lines long, equally canescent-downy on both sides. Peduncles from all the upper axils, 2 or 3 inches long. The very compact spike an inch long in flower, 2 inches long in fruit. Flowers about 4 lines long, on very short pedicels: the corolla apparently white or ochroleucous. Legumes 4 or 5 lines long, the valves strongly convex, rather thin coriaceous, and with a few transverse veins; the sutures acute, the ventral one only prominent. The species would be arranged among the *Scytocarp*i; but it is quite different from any other North American *Astragalus*.

The following new triphyllous species, from a region east of the Rocky Mountains, may be added.

ASTRAGALUS TRIDACTYLICUS: (*Triphylli*), habitu foliisque *A. triphylli* Pursh; floribus bis terve minoribus; calycis dentibus tubo æquilongis; corolla pallide purpurea; legumine globoso-ovoideo puberula calyce deciduo nudato; stipulis extus villosis. — Flores lin. 5 longi. Legumen lin. 3–4 longum, turgidissimum, 12-ovulatum. Semina matura 3–4, ratione leguminis magna. — Near Boulder City, Colorado Territory, in dense tufts or mats, on gravelly knolls, Dr. C. C. Parry, 1864.*

* Dr. Parry's collection of 1864 contains the following other *Astragali* which deserve notice: —

ASTRAGALUS JUNCUS, Gray, Rev., p. 230, with the teeth of the calyx in one specimen somewhat larger and sharper, so that this very rare species may pass into *A. diversifolius*.

ASTRAGALUS FENDLERI, Gray, just like the original, No. 157 of Fendler's collection, but probably passing into *A. flexuosus*.

ASTRAGALUS GLABRIUSCULUS, Gray (*Phaca*, Hook.), verging towards *A. aboriginum*, of which it is probably only a variety.

The genera *Horkelia*, Cham. & Schlecht., *Ivesia*, Torr. & Gray, and *Sibbaldia*, L., border so closely upon *Potentilla* that, for lack of absolute distinctions, they are not unlikely all to be referred to that already vast genus.* Such a combination, however, will hardly be thought satisfactory, even if unavoidable. The Linnæan genus, *Sibbaldia*, appears to have the least claims to its rank, having no peculiarity of habit, and comprising pinnate as well as trifoliolate species, which may well be regarded as *Potentillas* with the stamens, and in a less degree the carpels, reduced in number. If kept distinct, the deeply lateral styles will aid in separating *Sibbaldia* from the following.

Horkelia, however, if strictly limited, is pretty well marked in habit, and decidedly so in technical characters. These are the campanulate calyx and the (10) dilated filaments. This last and most distinguishing feature was omitted from the original generic character, and also from that of Endlicher.

Ivesia (striking out *I. gracilis*) I think should also be kept distinct from *Potentilla*, and probably from *Horkelia*. It cannot fail to be retained as a genus, if *Sibbaldia* is. There are now several species, all with the same peculiarity of foliage, which is quite unlike anything in *Potentilla*. Its characters are the campanulate or cyathiform calyx, the definite (5 to 20) stamens with slender filaments, and the few, in one instance even solitary, carpels.

In thus arranging these plants, it will be seen that there is one ambiguous and very troublesome species, viz. *Horkelia tridentata*, Torr., which, with the calyx and nearly the habit of *Horkelia*, has slender filaments. They are not, however, filiform, nor inserted, with the petals, at the bottom of the calyx, as represented in the plate. They are short, and inserted in the throat of the calyx, as in *Horkelia*, from which they differ only in being subulate. My specimen is insufficient.

HORKELIA, Cham. & Schlecht.

Calyx campanulatus, 10-fidus. Petala unguiculata seu spatulata (alba vel rosea). Stamina 10, fauci calycis inserta: filamenta brevia, dilatata, plerumque deltoidea petaloidea persistentia. Carpella plurima, nunc pauciuscula, in receptaculo villosa parvo elevato insidentia:

* This has been done in the yet unpublished second part of Bentham and Hooker's *Genera Plantarum*.

stylus cum ovarii apice articulatus. — Pinnatifoliæ, plurifoliolatæ; foliolis subsparsis sæpius incisis vel partitis, superioribus confluentibus.

§ 1. Genuinæ.

* Foliolis subrotundis cuneatisve dentatis incisisque.

+ Calycis segmentis accessoriis vera adæquantes vel iis subconformia. Cymæ subfolioso-bracteatae, floribus alaribus longius pedicellatis.

1. HORKELIA CALIFORNICA, Cham. & Schlecht. *H. grandis*, Hook. & Arn. *H. capitata*, Torr. Bot. Whipp., non Lindl. — California. Accessory calyx-lobes, or some of them, only occasionally bifid at the apex or toothed. In one specimen, from Los Angeles, Wallace, in a single flower only, there is a broadly subulate sterile filament, longer than the fertile ones, between each petal and its anteposed stamen!

Var. β . CUNEATA. *H. cuneata*, Lindl., I cannot distinguish as more than a smaller variety of Chamisso's species, with accessory calyx-lobes more conformed to the true ones, leaflets smaller, more cuneate, &c.

Var. γ . SERICEA: pube molli sericea subcanescens. — Oakland, near San Francisco.

++ Calycis segmentis accessoriis quam vera multo minoribus.

2. HORKELIA PARVIFLORA, Nutt. Oregon, Nuttall. Nevada, Dr. Newberry, Dr. C. L. Anderson.

3. HORKELIA CAPITATA, Lindl. Oregon, Douglas.

* * Foliolis angustis lobatis seu profunde incisis, laciniis lobisve linearibus; stipulis laciniatis vel pectinatis. Calycis segmentis accessoriis linearibus vel subulatis. Cymæ demum perfectæ multifloræ.

4. HORKELIA FUSCA, Lindl. Subviscoso-pubescent; foliis demum glabratis; petalis anguste cuneatis obcordatis. — Oregon, Douglas.

5. HORKELIA CONGESTA, Hook. *H. hirsuta*, Lindl. Villosobarbata, superne denudata; petalis late obovatis vel rotundatis ungue angusto. S. Oregon, Douglas, Nuttall. N. California, Newberry.

6. HORKELIA TENUILOBA. *H. fusca* var. *tenuiloba*, Torr. Bot. Whipp. Pacif. R. R. Surv. 4, p. 84. Villosocanescens; foliolis brevibus (lin. 3–4 longis) ambitu cuneatis profunde palmato-4–8-partitis, sinu medio sæpe profundiori, lobis linearibus; calycis segmentis accessoriis linearibus vera lanceolata subæquantibus; petalis anguste oblongo-spathulatis emarginatis; filamentis lanceolatis. — Santa Rosa

Creek, California, Dr. J. M. Bigelow. — Pubescence more like that of *H. congesta*, but softer, shorter, and less shaggy. Flowers small; petals 3 lines long, narrow, not unguiculate.

§ 2. *Ambiguæ* (an *Ivesia* ?); filamentis subulatis.

7. *HORKELIA TRIDENTATA*, Torr. Bot. Whipp. l. c., t. 6. California, Dr. J. M. Bigelow.

IVESIA, Torr. & Gray, pro parte.

Calyx campanulatus vel basi cyathiformis, 10-fidus. Stamina definita (5, 10, 15, 20): filamenta gracilia (tenuiter subulata vel filiformia). Carpella pauca, quandoque solitaria, in receptaculo parvo villosa: stylus subterminalis. — Pinnatifoliæ, millefoliolatæ, foliolis parvis palmati- seu pedatipartitis creberrimis nunc quasi-verticillatis vel rhachin undique imbricantibus, petalis late obovatis vix unguiculatis post anthesin spathulatis.

* Flavifloræ, 5–10-andræ, glabellæ; foliis plerisque radicalibus; scapo apice congestifloro.

1. *IVESIA GORDONI*, Torr. & Gray in Newberry, Rep. Pacif. R. R. Exped. 6, p. 72. (*Horkelia Gordoni*, Hook. Kew Jour. Bot. 5. p. 341, t. 12. *H. millefoliata*, Torr. in Sitgreaves Zuni Exped.) Spithamææ caudice crasso, viscido-pubens vel glabrata; foliolis confertis 5–9-partitis, segmentis obovato-spathulatis obtusis; cyma capitata pluriflora; calycis mox turbinati lobis ovatis demum triangularibus quam accessori oblongi demum sublineares longioribus; staminibus 5; receptaculo longe villosa; carpellis 10–14. — Besides the New Mexican habitats, we have what appears to be a dwarfer and alpine form (from which the above character is mainly drawn) of the same species, collected by Professor Brewer in the Sierra Nevada, at Ebbett's and Sonora Pass, near Soda Springs, &c., at the altitude of 8,700 to 10,800 feet; in flower and with young fruit. The fruiting specimens are very well represented by Hooker's figure. The golden-yellow petals, at first almost orbicular, become spatulate or even oblanceolate after anthesis, and then shorter than the accrescent calyx-lobes, as delineated and described by Hooker. Stamens only 5, alternate with the petals.

2. *IVESIA LYCOPODIODES*, sp. nov. Nana (sesqui-tripollicaris), fere glabra; foliis in caudice crasso cæspitoso-confertis, pinnis quasi verticillatis creberrimis, foliolis minimis 5–7-sectis, segmentis obovato-rotundis crassiusculis rhachin undique imbricantibus; scapo capitato-

3-5-floro; staminibus 5; receptaculo longe villosa; carpellis 5-10. — High alpine region of the Sierra Nevada, on Mount Dana, alt. 11,000 to 12,000 feet. (Also Bear Mountain, Mariposa, Miss Errington, ex Torr.) Leaves only an inch long; the leaflets and their divisions less than a line in length, nearly sessile, so crowded on the rhachis and imbricated that the leaves may be likened to the shoots of a minute tufted *Lycopodium*. Flowers like those of the preceding species, except in size, only a quarter of an inch in diameter. Fruit not seen.

3. *IVESIA PYGMÆA*, sp. nov. Habitu præcedentis, sed minutim glandulosa; foliolis minus confertis, segmentis oblongis setam nunc setulas 2-3 accessorias gerentibus; bracteis calycibusque parce hirsutis; staminibus 10; receptaculo breviter piloso; carpellis circiter 7. — Among rocks in the Sierra Nevada, from 11,000 feet (where it abounds) up to 12,000 feet; Prof. Brewer, coll. 1864. — This, more than the last, resembles *I. Gordoni* on a diminished scale; and it is possible that all three may run together. This, however, in the specimens, is distinguished by some hairiness, especially on the calyx, by the bristle which conspicuously tips each little leaflet or segment, by the less villous receptacle, and by the 10 geminate stamens.

* * Albifloræ, 15-20-andræ; caulibus gracilibus magis foliatis; cyma paniculata; foliis albido-lanatis myosuroideis; filamentis gracilimis.

4. *IVESIA PICKERINGII*, Torr. in Bot. Wilkes Pacif. Exped. (Calif. & Oregon), t. 4. Pedalis; foliis primum myosuroideis, foliolis demum patentiusculis 3-5-partitis sectisve, segmentis oblongis; pedicellis calyce (fructifero obconico-campanulato) brevioribus; lobis accessoriis calycis ovato-lanceolatis; staminibus 20 manifeste triseriatis; antheris mucronulatis; carpellis 4-6. — Coll. by Dr. Pickering, &c., on the journey from Oregon to California, probably on the Sacramento. (Character from a fragment, and from the plate cited.)

5. *IVESIA SANTOLINOIDES*, sp. nov. Spithamæa; foliis myosuroideis; foliolis minimis 3-5-sectis (segmentis ovalibus obtusis) appressis rhachin arctissime imbricantibus; pedicellis primariis elongatis filiformibus; floribus parvis; calycis tubo cyathiformi lobis propriis dimidio brevioribus, lobis accessoriis parvis ovatis; staminibus 10?-15; antheris didymis haud apiculatis; carpello unico in fundo calycis sub lana occulto. — In the Sierra Nevada. This is to *I. Pickeringii*, what *I. lycopodioides* is to *I. Gordoni*: its myriad minute leaflets or segments

(barely half a line in length) most closely imbricated all around the rhachis, so that the leaf ($1\frac{1}{2}$ to 2 inches long) resembles a mouse-tail, when young clothed with soft silky down, which conceals the parts beneath. When old the leaflets are more apparent, but they seem to remain permanently imbricated. Flowers, when expanded, scarcely 3 lines in diameter; the petals exceeding the calyx, roundish-flabelliform, and scarcely at all unguiculate, becoming obovate after anthesis. Fruit not seen.

Ivesia gracilis, Torr. & Gray, in Newberry, Rep. l. c., t. 11, = *Potentilla Newberryi*, Gray.

EPILOBIUM OBCORDATUM: nanum, glabrum; caulibus (3–5-pollicaribus) decumbentibus 1–5-floris; foliis oppositis lato-ovatis ovalibusque subintegerrimis opacis glaucescentibus; alabastris nutantibus; calycis tubo ultra ovarium pruinoso-puberulum producto infundibuliformi lobis lato-lanceolatis subdimidio brevioribus; petalis magnis læte roseis obcordato-bilobis patentibus; stylo stamina superante declinato; stigmatibus breviter quadrilobis; capsulis pedicellatis clavato-oblongis. — In the Sierra Nevada, at Squaw Valley and Ebbett's Passes, alt. 8,000–8,500 feet. — A charming alpine species, connecting the *Chamænerion* with the other sections of the genus, and with large and showy flowers, having the aspect of an *Enothera* or a *Clarkia*. The leaves are numerous, mostly longer than the internodes, closely sessile, and only from one third to two thirds of an inch in length. [Also found recently by Dr. Torrey.]

EUCHARIDIUM BREWERI: foliis oblongo-lanceolatis; petalis latissime cuneato-obcordatis cum lobo intermedio lateralibus longiori valde angustiori; filamentis apice eximie clavatis; antheris villosociliatis; stigmatibus 2–4-partitis (sæpius bipartitis segmentis elongatis bilobis); capsula elongata (ultrapollicari); seminibus magis alatis. — Dry summit of Mount Oso, at the elevation of about 3,200 feet. — This would be a fine acquisition to the gardens, as the flowers are larger and fuller than those of *E. concinnum*, the petals fully three fourths of an inch wide, very broadly cuneiform-obcordate with a narrow linear-spatulate median lobe (not exceeding two lines in width) in the deep sinus. The filaments, also, instead of being filiform, are conspicuously dilated at the summit, where they are broader than the linear anther, apparently clavate rather than petaloid. The villosity of the anthers, which is here very striking, is found sparingly in *E. concinnum*.

MITELLA (**MITELLARIA**, licet stam. petalis altern.) **BREWERI**: foliis omnibus radicalibus rotundato-remiformibus incise duplicato-crenatis brevi-petiolatis; scapo (spithamæo) nudo; calyce explanato 5-undulato; staminibus 5 petalis pectinato-pinnatifidis alternis. — Mount Hoffmann, in a damp place, at the elevation of about 11,000 feet. The outline and crenation of the leaves and the short (shaggy-hirsute) petioles distinguish this at a glance from *M. pentandra*, with which it accords in the structure of the flower, in the two two-lobed sessile stigmas, &c.; but here the very short filaments are inserted before the calyx-lobes, instead of before the petals. This is all that was needed thoroughly to suppress *Drummondia* of De Candolle (*Mitellopsis*, Meisn.).

SAXIFRAGA BRYOPHORA: *Arabidia*, *S. stellari* et *leucanthemifolia* proxima; foliis abbreviatis oblanceolatis lineari-oblongisve aveniis integerrimis ciliatis sessilibus sæpissime rosulatis; scapis aphyllis paniculato-ramosis, ramis elongatis flore unico perfecto terminatis, pedicellis lateralibus plurimis racemosis filiformibus mox refractis proles gemmiformes (flores mutatos) gerentibus; sepalis lato-ovatis; petalis lanceolato-ovatis basi abruptis bimaculatis; stylis vix ullis. — Ebbett's Pass, and on a peak near Mount Dana, alt. 9,000 feet, on wet rocks. — Leaves half an inch or less than an inch long. Scapes a span high, usually with divergent branches; the fertile and gemmiferous pedicels half an inch or less in length; some of the gemmæ are mere altered flower-buds; others are rosulate tufts from which a shoot is proceeding. This bears much the same relation to *S. leucanthemifolia* that *S. stellaris* var. *comosa* does to ordinary *S. stellaris*. But the small and quite entire leaves, and the reflexed filiform pedicels of the gemmæ are peculiar.

Some new materials and observations make it desirable to revise the genus.

LITHOPHRAGMA, Nutt., Torr., & Gray.

* Petala lamina tripartita, segmentis angustis: folia omnia partita vel infima lobata: radix (quandoque caulis) bulbillifera.

1. **LITHOPHRAGMA GLABRA**, Nutt. Glabella; racemo axillisque foliorum sæpe bulbilliferis; pedicellis calyce campanulato pubero longioribus; ovario basi tantum calyce adnato; seminibus muriculatis. — Blue Mountains of Oregon, Nuttall. Pine forests on small tributaries of the Upper Sacramento, California, Fremont. Rocky Mountains in Colorado Territory, mixed with *Saxifraga cernua*, Hall and Har-

bour. — It must have been through some mistake that, in the Flora of North America, this species was placed in the section with an adherent ovary.

2. *LITHOPHRAGMA TENELLA*, Nutt. Glanduloso-hirsutula; foliis minus dissectis; pedicellis calyce primum obconico dein campanulato æquilongis; ovario infra medium adnato; seminibus lævibus. — Rocky Mountains. The only specimens are the original, scanty, and apparently depauperate ones of Nuttall. The plant resembles a diminutive *L. parviflora*, with less divided leaves, and a campanulate calyx, the base of which is certainly adnate to the lower part of the ovary. The seeds are much smaller and oval.

3. *LITHOPHRAGMA PARVIFLORA*, Nutt. (*Tellima parviflora*, Hook. Fl. Bor.-Am. 1. p. 239, t. 78.) Scabro-hirta; pedicellis suberectis calyce obconico (fructifero nunc clavato) creberrime glanduloso-hirtello sæpius brevioribus; ovario ultra medium adnato; seminibus lævibus oblongis. — Rocky Mountains and Oregon, to Vancouver's Sound.

The plant referred to this species in Ives's Colorado Expedition, collected by Dr. Newberry on hills along Cedar Creek, in the western part of New Mexico, is, from the calyx, &c., more like *L. tenella* on a larger scale, but probably is of a different species, not to be made out satisfactorily with the extant materials. It bears some granules or bulblets on the base of the stem, which have not been detected in any of the following species.

* * Petala lamina dilatata triloba, raro integra: folia radiculia reniformi-rotundata subindivisa vel crenato-lobata, superiora 3-5-fida vel partita: bulbilli ad radices, etc., nulli. Flores majusculi.

4. *LITHOPHRAGMA AFFINIS*, sp. nov. Scabro-hirta, 1-1½-pedalis; floribus modice pedicellatis; calycis creberrime glanduloso-hirtelli tubo turbinato ad apicem fere ovarii adnato; stylis granulosis; petalis maxime dilatatis apice trilobis; seminibus lævibus. — This has been confounded with *L. heterophylla*, and it is apparently as common in California around and north of San Francisco, where Dr. Brewer has abundantly gathered it, at several stations. To it belongs the specimens (named *L. heterophylla*) collected by Dr. Bigelow in Whipple's Expedition, a part of Dr. Parry's, collected at Monterey, in the Mexican Boundary Survey, Thurber's from Napa County, and specimens from Ross, long ago distributed by the St. Petersburg Academy. It is at once distinguished from the next by the calyx tapering to an

acute base, and the ovary almost wholly inferior. It is commonly a larger plant; the petals are from one third to nearly half an inch in length, their middle lobe occasionally laciniate-toothed. The pedicels are usually about the length of the fruiting calyx.

5. *L. HETEROPHYLLA*, Hook. & Arn. sub *Tellima*. Scabro-hirta, subpedalis; pedicellis brevissimis; calyce lato-campanulato minus hirta, fructifero basi quasi truncato; ovario libero stylisque glabris; petalis trilobis; seminibus muriculatis. — California, common near the coast, and northward. — The difference in the seeds (which are smaller and rounder as well as muriculate) may assure us that the case of this and the foregoing is not one of dimorphism. There appears also to be a slight difference in the anthers.

6. *LITHOPHRAGMA BOLANDERI*, sp. nov. Major (1-2-pedalis, foliis sæpe 1-2-poll. latis), hirsutulo-scabrida; racemo elongato plurifloro; pedicellis brevissimis seu calyce lato-campanulato (fructifero basi quasi truncato) dimidio brevioribus; ovario ima basi excepta libero; petalis nunc integerrimis nunc leviter trilobatis vel dente utrinque instructis; seminibus muricatulo-scabridis. — California, in a shady ravine, S. E. of Monte Diablo (Dr. Brewer), and farther north in the Mendocino district, H. N. Bolander. — The largest species: petals white, 3 or 4 lines long, more commonly all entire, sometimes all but one of the flowers more or less toothed or even lobed. Styles, as in the next, very short and glabrous. A slender form, in herb. Torrey, was collected in the valley of the Sacramento by Dr. Stillman.

7. *LITHOPHRAGMA CYMBALARIA*, Torr. & Gray (*Saxifraga Californica*, Nutt. mss.). Exilis, glabella; caule scapiformi (6-14-pollicari, foliis $\frac{1}{3}$ - $\frac{2}{3}$ -poll. diam.) 4-7-floro; pedicellis calyce campanulato-cyathiformi (basi acuto) longioribus; ovario basi adnato; petalis spathulatis oblongisve integerrimis; seminibus muricatulo-scabridis. — Near Santa Barbara, Nuttall, Parry, Brewer, in cañons. Cauline leaves sometimes a pair and opposite or nearly so, sometimes alternate, occasionally almost obsolete. Lobes of the calyx *much shorter* than the tube except in Nuttall's very depauperate specimen. Petals, in good flowers, 3 or 4 lines long.

CYOPTERUS CINERARIUS: parvus; caudice repente; petiolis basi scarioso-dilatatis sursum scapisque gracilibus (1-3-pollicaribus) glaberrimis; folio decomposito ambitu subcordato glauco-cinereo pruinoso-puberulo, segmentis lobisque confertissimis; umbellulis 1-4 (sæpe

solitariis) capitatis involucellum completum multifidum (lobis ex ovato subulatis) subsuperantibus; floribus albidis roseisque; calycis dentibus parvis obtusis; fructibus 10-alatis, alis suberoso-scariosis maxime undulatis; semine ventre intus profunde excavato.—In volcanic ashes, on dry hills in the high Sierra Nevada, at Sonora Pass, and above Lake Mono, alt. 9–10,000 feet. Leaves and scapes emerging from a subterranean creeping rhizoma; the lamina of the former mostly less than an inch in diameter, the divisions extremely crowded, the ultimate lobes a line or rarely two lines long, oblong, obtuse, mucronate. Scape commonly exceeding the leaves. Involucel nearly herbaceous. Pedicels extremely short. Fruit 3 lines long, with complete, rather broad, white (or purplish-tinged) and much undulate wings: vittæ 3 in each interval and a few on the commissure. Seed deeply excavated at the commissure, the cross-section strongly reniform, more so than in *C. montanus*, &c. (noticed in Pl. Fendlerianæ, p. 57); so that the fruit is decidedly campylospermous.

CYOPTERUS FENICULACEUS, Nutt., as I suppose it to be, also collected by Dr. Brewer in the Sierra Nevada, is almost equally campylospermous. It is hoped that the primary divisions in this order may yet be established upon other characters than the form of the seed.

CYOPTERUS? NEVADENSIS: depresso-cæspitosus, glaucus, fere glaber; petiolis brevibus, basibus scarioso-dilatatis caudices breves vestientibus; lamina foliorum 3–7-partita, segmentis rigidis lato-lanceolatis cuspidatis, lateralibus raro 2–3-fidis; scapo ($\frac{1}{6}$ – $\frac{1}{2}$ -pollicari) folia parum superante umbellam capitatam quasi simplicem gerente; involucellis 4–5 lateralibus 3-fidis flores (flavidos?) adæquantibus involucrum simulantibus.—At and near the summit of Mount Dana, one of the highest peaks in the Sierra Nevada, alt. 13,227 feet. In flower only, the genus quite uncertain. Plant only an inch or two in height, tufted. Leaves and scapes obscurely puberulent. Umbel 3 or 4 lines in diameter, composed of 3 to 5 subsessile umbellets, each adnate to the base of a foliaceous 3–5-cleft involucel (the divisions ovate); these involucels imitating a complete common involucre. Pedicels scarcely any. Ovary showing obscure rudiments of wings. Calyx-teeth lanceolate-subulate. Styles long and slender.

SPHENOSCIADIUM, nov. gen. *Angelicearum*.

Calycis margo obsoletus. Petala spathulato-obcordata, cum lacinula setaceo-acuminata inflexa. Styli filiformes. Fructus cuneatus: meri-

carpia compressa sursum sensim quinquealata; alis suberosis, marginalibus latioribus; valleculis univittatis; commissura bivittata. Carpo-phorum bipartitum. Semen more *Cymopteri* sectione transversa planiusculo-lunata. — Herba Californica; radice fusiformi; caule valido fistuloso usque ad umbellas cum foliis sub-bipinnatisectis glabro; umbellis tomentosis exinvolucratis; involucellis multipartitis flores albos sessiles densissime capitatos subæquantibus.

SPHENOSCIADIUM CAPITELLATUM. — In the Sierra Nevada, near Ebbett's Pass, alt. 7–8,000 feet, by a stream; in flower. Nevada, near Carson City, Dr. C. L. Anderson; with fruit. Root rather strong-scented, acrid. Stem 2 to 5 feet high, striate. Petioles spathaceous-dilated. Divisions of the leaves ovate- or oblong-lanceolate, about an inch long, coarsely and sharply few-toothed or incised; veinlets finely reticulated. Umbel 7–10-radiate; the umbellets are globose heads, 4 or 5 lines in diameter, in fruit about three fourths of an inch; the flowers (pubescent) sessile on a dilated receptacle, to which the short involucrel is somewhat adnate. Fruits 3 lines long, pubescent; the mericarps (including the wings) obovate-cuneate or obscurely obcordate; the narrow base strongly 5-ribbed; but the corky ribs enlarge towards or at the summit into thickish wings, the lateral ones being the broadest, sometimes nearly as broad as the seed. A thick vitta in each interval, and two submarginal ones on the commissure.

Loniceræ (Xylosteon) Breweri: caule erecto; foliis ovalibus vel obovatis pubescentibus breviter petiolatis; pedunculis folio sublongioribus; ovariiis urceolato-oblongis basi coadnuatis; bracteolis minimis; corolla lurido-purpurea campanulata late gibbosa ultra medium bilabiata; fauce styloque hirsutissimis. — In a ravine of the Sierra Nevada, near Mount Dana, at the elevation of about 10,000 feet. — Allied to *L. nigra* of the Old World; but the leaves (only an inch or less in length) rounder, much more pubescent, and of a different venation; the ovaries narrower, and crowned with subulate calyx-teeth, the corolla more gibbous, the style hirsute, &c.

GALIUM ANDREWSII: pulvinato-cæspitosum; rhizomatibus longis filiformibus; foliis crebris quaternis subulatis setuloso-apiculatis rigidis nitidulis glabris aut fere nudis aut cum angulis caulium pl. m. spinulosociliatis, costa valida; pedunculis 1–3-floris nudis; floribus albidis; fructu lævi. — Var. *a. gracilius*; foliis lineari- vel aciculari-subulatis margine aut parce aut rarissime spinuliferis: pedunculis folia adæquan-

tibus. — β . compacte pulvinatum; pedunculis brevissimis unifloris, foliis subulatis creberrimis. — γ . compactum; pedunculis foliis brevioribus 1-3-floris; foliis latioribus lanceolato-subulatis ad margines angulosque acutissimos caulium crebrius spinuliferis. — California, Dr. Andrews, Mr. Shelton (Herb. Torrey). Near Fort Tejon, Dr. Horn, Dry Hills, Atascadero (var. α), and Santa Inez Mountains near Santa Barbara (var. β), near Kirka Pass (var. α), and near Monterey? (var. γ), Dr. Brewer. — The laxer forms have the aspect of *G. orientale*, the more condensed, of *G. Pyrenaicum* and *G. Cylleium*, Boiss.; and the species is very different from any other North American one. The Chilian *G. hypnoides*, Clos, is similar, but its leaves are nearly destitute of costa, and it is said to have a distinct limb to the calyx. The fruit apparently dry; no involucre or whorl of bracts on the peduncle. Plants from two inches to a span high.

GALIUM BLOOMERI: glaberrimum, inerme, erecto-diffusum; foliis quaternis ovatis cuspidato-acuminatis subtrinerviis opacis, floralibus sæpe tantum oppositis; floribus abortu dioicis, masculis cymulosis brevipedunculatis, foemineis subsolitaris subsessilibus; corolla ut videtur ochroleuca; fructu (juvenili) hirsutissimo. — Nevada Territory, near Virginia City, Mr. H. G. Bloomer, to whom, as its discoverer, and an ardent devotee to Botany, I have much pleasure in dedicating this very well-marked species. The specimens are a foot or less in height, from a perennial or suffrutescent base. Stems paniculately branched. Leaves 3 to 5 lines long, closely sessile, rather rigid, veinless, the midrib evident, the larger leaves with a pair of lateral ribs, which vanish near the middle. Corolla a line and a half in diameter. The nature of the verticil is well shown in some of the floral leaves, which are reduced to a pair, sometimes slightly connate by a transverse membranous line, and sometimes with a smaller bifid or bidentate leaf interposed on each side, this evidently answering to a connate pair of stipules.

GALIUM HYPOTRICHUM: humile, pube minuta cinerea scabridum, inerme; foliis quaternis ovatis apiculatis subtrinerviis, floralibus oppositis; floribus submonoicis vel hermaphroditis parce cymulosis; pedicellis flore longioribus post anthesin recurvis; fructu (juvenili) juxta basin setis longis crinito, cæterum lævi. — Sonora Pass, in the Sierra Nevada, alt. 8,000 to 9,000 feet, in dry and rocky places. — A span high; apparently tufted, in habit, foliage, &c., much resembling the

preceding species ; the flowers smaller, apparently white or yellowish. The bristly hairs on the forming fruit are rather few, much longer than the ovary, and all confined to its base. The floral leaves, in simple pairs, often show minute interposed stipules.

KELLOGIA GALIODES, Torr. in Bot. S. Pacif. Ex. Exped. coll. N. W. Amer. Phænog. t. 4. — This interesting plant, which, we believe, was discovered in the northern part of California, has now been collected by Dr. Brewer [and more recently by Dr. Torrey himself], in the foot-hills of the Sierra. It is, as it were, an *Asperula* with opposite leaves and scarious interposed stipules.

MACHÆRANTHERA (*HESPERASTRUM* ; ligulæ steriles) *SHASTENSIS* : nana, e caudice perenni multicaulis, tomentuloso-canescens ; caulibus 1 – 2-cephalis ; foliis integerrimis obtusis, inferioribus spatulatis subtrinnatis, superioribus oblongis subamplexantibus ; involucri campanulati squamis lanceolato-linearibus sæpius acutis, extimis apice herbaceis, interioribus tenuioribus inappendiculatis ; ligulis “ roseo-violaceis ” ? — Northern California, on Mount Shasta, at the height of 9,000 feet. Very little of this was found. It is a dwarf alpine plant (3 to 6 inches high, the lower leaves less than an inch long, the upper cauline successively smaller), with the aspect, styles, and generally the character of *Machæranthera*, except the perennial root and completely neutral rays, or of *Aster*, excepting the last-named particular. As it has neither the peculiar appendages to the style nor to the anthers of *Lessingia* and *Corethrogyne*, I cannot refer it to the latter genus, but on the whole conclude to append it to *Machæranthera*. The ovaries are scarcely compressed. Involucre 3 or 4 lines in diameter.

ASTER BLOOMERI : depressus, cæspitoso-diffusus ; ramis foliosis apice monocephalis ; foliis parvis (3 – 6 lin. longis) oblongo-linearibus imisve lineari-spatulatis sessilibus uninerviis aveniis hispidulo-scabris et ciliolatis ; involucri hemisphærici squamis subtriseriatis lineari-lanceolatis acuminatis dorso vel apice herbaceis minute granuloso-glandulosis laxiusculis ; ligulis pallide violaceis ? — On high slopes of Mount Davidson, near Virginia City, Nevada, H. G. Bloomer. A peculiar little species, to be ranked, perhaps, with the *Ericoidei*, but not obviously related to any other. Stems tufted from a somewhat lignous caudex, the branches very leafy nearly to the heads ; the leaves uniform. Heads about 4 lines in diameter, exclusive of the rays. Appendages of the style subulate. Achenia pubescent. Pappus soft.

ERIGERON (CELMISIA) ANDERSONII: lana tenui arachnoidea mox decidua glabratum; caulibus e rhizomate nudo adsurgente erectis simplicissimis apice nudo monocephalis; foliis coriaceis linearibus acutis, radicalibus elongatis (spithamæis) 3-5-nerviis deorsum attenuatis, caulinis brevibus basi latoribus in bracteas subulatas decrescentibus; capitulo hemisphærico majusculo ($\frac{2}{3}$ -pollicari); involucri lanulosi squamis lineari-lanceolatis subherbaceis parum biseriatis; ligulis uniseriatis exsertis lato-linearibus (cæruleis vel purpureis); styli ramis fl. herm. filiformibus, parte hispida quam stigmata 3-4-plo longiori; acheniis oblongo-linearibus villosis 4-6-costatis; pappo uniseriali, setis æqualibus barbellulatis. — Nevada, near Carson City, Dr. C. L. Anderson. Lake Tenaya in the Sierra Nevada, Prof. Brewer, a single depauperate specimen. Stems a span to a foot high: the rigid leaves soon glabrous. Bristles of the pappus all alike, but with a few minute setulæ intermixed, as in most *Erigerons*. This is a North American representative of the Andine group of species, sometimes referred to *Aster*, which Schultz has recognized as identical with *Celmisia*, and Weddell has referred to *Erigeron*. I am constrained by the uniseriate pappus, etc., to adopt the same view, rather than to refer this plant to *Aster*. But the long and filiform appendages of the style (resembling those of some of its South American relatives) are most unlike those of the true *Erigerons*. The several species of *Celmisia* differ greatly in the form of the style.

ERIGERON CONCINNUM, Torr. & Gray, var. *APHANACTIS*, ligulis abortivis stylo brevioribus eradiatum. — Near Carson City, Nevada, Dr. C. L. Anderson. Virginia City, H. G. Bloomer.

ERIGERON BLOOMERI; nanum, multiceps e radice fusiformi; foliis plerisque radicalibus confertis fere filiformibus cum scapis monocephalis pube minuta appressa cinereis; involucri lanato-villoso, squamis subæqualibus disco parum brevioribus; ligulis plane nullis; acheniis plano-compressis hirsutulis; pappo simplicissimo. — Nevada, near Virginia City, H. G. Bloomer; near Carson City, Dr. C. L. Anderson. Scapes about three inches high, twice the length of the leaves, naked above, 2-3-leaved towards the base. Heads about twice the size of those of *E. filifolium*, the involucre clothed with copious white and soft hairs. Pappus a little shorter than the tubular corollas. Achenia flat, with a nerve only on each margin. Appendages of the style short and acute.

ERIGERON BREWERI: *Pseuderigeron*, pube minuta cinereum; caulibus e rhizomate tenui repente adsurgentibus gracilibus usque ad apicem corymboso-1-5-cephalum foliosis; foliis oblanceolatis seu lineari-spathulatis uninerviis integerrimis; pedunculis brevibus; involucri fere glabro disco maturo dimidio brevioribus, squamis 2-3-seriatis inæqualibus; ligulis elongatis uniserialibus (ut videtur violaceis); acheniis parce hirtellis; pappo duplici, exteriori brevi setuloso. — Yosemite Valley, alt. 4,000 feet; in flower. Near Carson City, Nevada, Dr. C. L. Anderson; in fruit. Stems mostly simple from the base, a span to a foot high. Leaves an inch or less in length, mostly narrow-spatulate and obtuse. Heads smaller than those of *E. foliosum*, Nutt. (*E. Douglasii*, Torr. & Gray); the involucre more imbricated, as in *E. Bigelovii*, but decidedly shorter. Pappus as long as the disk-corolla. Appendages of the style very short and obtuse. Achenia linear, flat, 2-nerved.

LINOSYRIS (CHRYSOETHAMNUS) HOWARDII, Parry, in litt.: fruticosa, semi-sesquipedalis; ramis junioribus lanoso-dealbatis; foliis linearibus acutatis uninerviis glabris (primum tenuiter arachnoideis), floralibus capitula corymboso-congesta superantibus vel subæquantibus; involucri 5-floro cylindraceo, squamis laxiusculis lanceolatis omnibus modo *L. Parryi* attenuato-acuminatis; corollæ pallide flavæ tubo parce villosulo; acheniis linearibus pubescentibus. Var. *a.* foliis angustissime linearibus elongatis; involucri tenuissime arachnoideo glabrato. — Colorado Territory, on gravelly hills near "Hot Springs" of Middle Park, where it is often associated with *L. Parryi*, Gray, coll. C. C. Parry, 1863. It is more shrubby than that species, its smaller and fewer-flowered heads in terminal, fastigate, almost capitate clusters, &c. A little of it was included under Hall and Harbour's No. 293.

Var. *β.* NEVADENSIS: foliis pl. m. latioribus brevioribus (inferioribus subspathulato-linearibus), apice cuspidato sæpius incurvo; involucri squamis præsertim ad margines magis arachnoideis subviscosis. — Mount Davidson, Nevada, above Virginia City, H. G. Bloomer. Near Carson City, Dr. C. L. Anderson. Ebbett's Pass, within the borders of California, alt. 9,000 feet, Prof. Brewer; a dwarf form, only 5 or 6 inches high.

APLOPAPPUS BLOOMERI: suffruticosus, pedalis, subresinosus, glaber; ramis fastigiatis usque ad apicem foliosis corymboso- (vel subpaniculato-) polycephalis; foliis subspathulato-linearibus basi attenuatis

VOL. VI. 61

rigidis uninerviis vel inferne obsolete trinerviis; capitulis folioso-bracteatis; involucro subturbinato 3-4-seriali, squamis coriaceis lanceolatis pl. m. resinosis et villosa-ciliatis, exterioribus folioso-vel subulato-caudatis, intimis tenuioribus inappendiculatis; floribus radii 3-4 ligula oblonga exserta, disci 15-20; acheniis linearibus pubescentibus.— On Mount Davidson, Nevada, H. G. Bloomer. Near Carson City, Dr. C. L. Anderson, with a very narrow-leaved and more loosely corymbose-headed form. Leaves from one to barely 2 inches long. Heads crowded, about half an inch long; and the ligules 4 or 5 lines long. Anthers and style exserted; the short branches of the latter bearing long subulate-filiform appendages, as in *Linosyris* section *Chrysothamnus*, *Aplopappus* section *Ericameria*, and in the following species, to which it is nearly related.

APLOPAPPUS SUFFRUTICOSUS (*Macronema suffruticosa*, Nutt.): spithamæus e basi depresso-ramosa lignosa, glanduloso-puberulus, subviscidus; ramis usque ad apicem foliosis sæpissime monocephalis; foliis linearibus seu lineari-subspathulatis acutatis uninerviis; involucro folioso-bracteato fere hemisphærico, squamis tantum biseriatis æqualibus laxis lineari-lanceolatis, extimis folioso-appendiculatis, intimis tenuioribus inappendiculatis, floribus radii 3-8 ligulis discum subsuperantibus, disci circa 30; acheniis linearibus pubescentibus.— Collected by Prof. Brewer in the eastern part of the Sierra Nevada, on Pyramid Peak, near Carson's Pass, alt. 8-10,000 feet.— This has no just claim to a separate generic rank, but must be referred, with the preceding, to *Aplopappus*.

APLOPAPPUS MACRONEMA, *Macronema discoidea*, Nutt., of which fine specimens were distributed in Hall and Harbour's Rocky Mountain collection, is distinguished from the last by the arachnoid-woolly branches, somewhat simpler involucre, and broader leaves, as well as by the absence of rays. The achenia are not glabrous, as described.

CHRYSOPSIS (AMMODIA) BREWERI: viscoso-subpubescens, laxè paniculato-ramosa; foliis oblongis seu ovato-lanceolatis membranaceis basi lata tenuiter trinervi arcte sessilibus; capitulis (nunc nudis graciliter pedunculatis nunc foliis 1-2 fulcratis) discoideis; involucro quam discus dimidio brevioribus, squamis lanceolatis acuminatis tenuibus; acheniis obovatis plano-compressis hirtellis; pappo exteriori setuloso satis copioso.— Near Sonora Pass and Ebbett's Pass, in the Sierra Nevada, common at the elevation of 4,000 to 8,000 feet.— This is a

close congener of *C. (Ammodia, Nutt.) Oregana*; but is at once distinguished by the above characters, and by its laxer inflorescence. The involucre is less imbricated and much shorter, scarcely exceeding the achenia, which are broad and flat. There is an evident setulose outer pappus, like that of *Chrysopsis villosa*, &c. A new examination of the Oregon species shows the same, only scantier. So I venture to regard Nuttall's *Ammodia* as a discoid section of *Chrysopsis*.

CHRYOPSIS BOLANDERI: § *Achyraea*, *C. pilosa* affinis, villosior; radice perenni; foliis superioribus acutioribus, summis conformibus capitula sessilia involuerantibus vel fulcrantibus paullo superantibusque; corollis disci extus parce arachnoideis; pappo exteriori e paleolis linearibus subulatisque achenio angusto cano-sericeo vix dimidio brevioribus. — Hills of Oakland, near San Francisco, abundant, H. N. Bolander. From the general character, and the foliose-bracted sessile heads, this would seem to be Nuttall's *C. sessiliflora* (from Santa Barbara), of which I find I have no specimen, though I must some time have examined it. But the present plant shows an outer pappus as conspicuous as that of *C. pilosa* itself, although of longer and narrower scales. A few scattered, long, arachnoid hairs are borne on the upper part of the disk-corollas.

SOLIDAGO GUIRADONIS: *Virgatæ*, glaberrima; caule gracili stricto; foliis anguste linearibus elongatis integerrimis, imis lanceolatis in petiolum marginatum longe attenuatis; panicula angustissima oligocephala; capitulis parvis; involucri squamis subulatis, costa crassa; ligulis 8–9 flores disci 10–12 haud superantibus; acheniis puberulis. — Along a brook at the base of San Carlos, coll. Guirado. Stem 2½ or 3 feet high, from a ligneous rhizoma. Lowest leaves 6 inches long, less than half an inch wide; the principal cauline leaves 3 inches long and only 2 or 3 lines wide, above gradually reduced to linear-subulate bracts, venulose. Heads 2½ lines long, erect, sometimes in almost a simple raceme. A very distinct species, named for the collector, a very intelligent young native Californian assistant in the surveying party, Guirado.

WYETHIA (ALARGONIA) GLABRA: *W. helenioides* proxima, sed glabra, pl. m. viscosa; foliis caulinis in petiolum brevem attenuatis; pappo calyciformi e paleis 5–8 ovatis vel triangulatis nunc basi nunc ad medium usque coalitis. — Marin County: specimen with the large head foliose-involucrate, as in many specimens of *W. helenioides*; the

cauline leaves obtuse and tapering into a short and margined petiole. Pass El Robles in Salinas Valley, south of San Luis Obispo, with a naked head (said to have the disk sometimes 4 inches in diameter, but in the specimens much smaller), and the cauline leaves more petioled. I have a radical leaf (about $1\frac{1}{2}$ feet long and $4\frac{1}{2}$ inches wide) and a head of this, collected by Dr. Andrews, probably near San Francisco.

W. helianthoides, Nutt. (of which, however, I have not present access to any specimen), *W. robusta*, Nutt., and *W. angustifolia*, Nutt., belong probably to one species. The following, with the aristiform pappus of the above, has the woolliness and aspect of *W. helenioides*, but much smaller heads.

WYETHIA MOLLIS: arachnoideo-lanata, ætate subdenudata; caule 1–3-cephalo; foliis oblongis ovalibus ovatisque omnibus petiolatis integerrimis; involucri squamis ovato-lanceolatis cum ligulis elongatis 10–12; acheniis linearibus e pappo breviter coroniformi longius biaristato vel in radio triaristato. — Mono Lake and summit of Sonora Pass in the Sierra Nevada. Also near Carson City, Nevada, Dr. C. L. Anderson; and in great patches on Mount Davidson at Virginia City, H. G. Bloomer. The Nevada specimens much more densely clothed with a coat of floccose white wool than those of Prof. Brewer: this may readily be rubbed off, and partly wears away from the old leaves. Radical leaves a foot or less in length, besides the stout petiole: cauline leaves 4 to 6 inches long. Scales of the involucre about an inch long, the outer and larger ones a little surpassing the disk, very woolly. Ligules an inch and a half long. Achenia about half an inch long, the subulate awns 3 or 2 lines long. — Mr. Nuttall regretted, as all must do, that this genus could not retain De Candolle's name of *Alarçonia*.

HELIANTHUS BOLANDERI: *Annui*; caule hirsuto bipedali et ultra ramoso; foliis omnibus alternis ovato-lanceolatis seu ovato-rhomboideis crebre sæpius grosseque serratis e basi attenuata trinerviis longe petiolatis; involucri squamis foliaceis lineari-lanceolatis sensim attenuatis acutissimis patentibus vix imbricatis hirsutis discum superantibus ligulas 10–12 subæquantibus; acheniis sericeis; pappi paleis 2 aristæformibus. — At the Geysers, Lake County, near Clear Lake, H. N. Bolander. The root is pretty clearly annual; and the species (with leaves somewhat like those of *H. petiolaris*, but much more serrate, &c.) is very different from any other we have. Heads small, the brown-purple disk less than an inch in diameter, the involucre resembling that of *H. decapetalus* or *H. tracheliiifolius*.

HELIANTHUS EXILIS: *Annui*, hirsutus, nunc tantum scaber; caule gracili pedali et ultra ramoso; foliis (oppositis superioribus alternis) lineari-oblongis lanceolatisve subintegerrimis basi obscure trinerviis in petiolum brevem attenuatis; capitulis pro genere minimis; involucri squamis 10–12 lanceolatis foliaceis laxis ligulis 5–8 subdimidio brevioribus; paleis receptaculi aristato-cuspidatis; acheniis glabris; pappi paleis ovato-lanceolatis.—In wet places about Clear Lake, H. N. Bolander. A glabrate form from Owen's Valley, Dr. Van Horn. Leaves an inch or an inch and a half long. Heads on almost filiform peduncles; the brown-purple disk only half an inch broad. Chaff of the receptacle truncate-tricuspidate with the middle point projected into a rigid awn, all but the outer chaff carinate-winged on the back.

PUGIOPAPPUS BIGELOVII, Gray in Torr. Bot. Whipp. Exped., Pacif. R. R. Rep. 4, p. 104. Add. char. gen.: Achenia plano-obcompressa; radii fertilia, ala suberosa cincta, calva; cætera inania, disco epigyno cylindrico styli basin cingente apiculata, paleis pappi pugioniformibus demum deciduis.—Prof. Brewer collected this very little known plant on dry hills at San Buenaventura, in the southern part of California, and also received it from Fort Tejon, collected by Dr. Van Horn, with some fruit.

CHÆNACTIS XANTIANA (*C. glabriuscula* var. *megacephala*, Gray in coll. Xantus, Fort Tejon, Jour. Bost. Nat. Hist. Soc., non Bot. Whipp.): *C. heterocarphæ* affinis, sed robustior, magis glabrata, caule fistuloso; *C. glabriusculam* var. *megacephalam* æmulans sed pappo duplici, paleis 4 interioribus lanceolatis corollam subæquantibus 4 exterioribus brevissimis late cuneato-obovatis vel obcordatis; ab utraque differt involucri squamis angustioribus laxioribus, corollis ut videtur carneis, marginalibus parum ampliatis cæteras haud superantibus. (Capitula majora fere pollicaria.)—This, the No. 45 of the collection made by Xantus near Fort Tejon, I confounded, as is noted above, with a different species; but we now have it, in fine state, from Dr. Anderson, who found it near Carson City, in Nevada.

Var. **INTEGRIFOLIA**: foliis anguste linearibus integerrimis rariusve 1–2-lobatis.—Near Fort Tejon, Dr. Van Horn.

CHÆNACTIS TANACETIFOLIA: humilis, lana tenui canescens, mox glabrata; foliis plerisque radicalibus bipinnatipartitis, segmentis lobisque confertis parvis oblongis seu ovalibus obtusissimis; caulibus scapisve (3–4-pollicaribus) monocephalis; involucri squamis lineari-

subspathulatis; corollis aureis, marginalibus ampliatis; pappo duplici e paleis 4 oblongis obtusissimis corolla (disci paullo, radii dimidio) brevioribus et 4 alternantibus minimis ovalibus. — Lake County, near Clear Lake, H. N. Bolander. A very distinct species, with Tansy-like leaves in a radical tuft, heads rather smaller than those of *C. lanosa*, and bright yellow flowers; it makes the third known species with a short outer pappus.

ACTINOLEPIS MULTICAULIS, DC., var. *PAPPOSA*: acheniis disci etiam pappo donatis. — Prof. Brewer's specimens, from three stations, all in Santa Barbara County, uniformly have a pappus to the disk, like that of the ray flowers. This is the same in specimens otherwise exactly resembling the plant on which the genus was founded, and in a more woolly form, gathered in Santa Maria Valley, which however, except in the pappus, would not be distinguished from Dr. Parry's specimens, figured in the Botany of the Mexican Boundary Survey. *Actinolepis* might accordingly be reduced to a section of *Bahia*: but the reception of the external achenia into a concavity at the base of the involucre scales may still enable us to keep the genus.

ACHYROPAPPUS WOODHOUSEI: humilis, ramosissimus, subviscoso-puberulus; foliis fere omnibus oppositis tripartitis, segmentis linearibus obtusis integerrimis vel intermedio trilobo; capitulis brevi-pedunculatis; involucri squamis obovato-oblongis; (floribus albidis?) ligulis parvis; cor. disci tubo gracili; pappi paleis 8–10 lanceolatis acutis (alternis sæpe brevioribus) nervo valido excurrente modo *Palafoxia* instructis. — New Mexico, Dr. Woodhouse, in herb. Durand. Apparently only a span high; the leaves all less than an inch long. Rays linear-oblong, a line and a half in length, scarcely exceeding the disk. Branches of the style tipped with a short and obtuse puberulent cone. This kind of style and the opposite divided leaves prevent us from referring the plant to *Palafoxia*, of which it has the pappus, nor will it fall into *Florestina*.

BURRIELIA LEPTALEA: fere glabra; caule vel ramis subradicalibus 1–3 capillaribus simplicissimis monocephalis; foliis perpaucis filiformibus parvis; involucri squamis 4–5 ovalibus oblongisve; ligulis totidem exsertis at disco maxime elevato brevioribus; acheniis parce hispidulis bi- (raro tri-) aristatis; aristis flores adæquantibus inferne sensim leviter dilatatis superne tenuissimo scaberrimo. — Santa Lucia Mountains, on very dry hillsides along the Nacimento River. Allied

to *B. microglossa*, and, like that species, having an acute appendage surmounting the branches of the style, and a very slender, subulate, naked-pointed receptacle ! The rays are more apparent, the involucrel scales wider, and the pappus more slender and rough.

LASTHENIA (MONOLOPIA) AMBIGUA : gracilis, arachnoideo-lanata ; caule spithamæo ramoso ; foliis alternis spathulato-linearibus lanceolatisve subintegerrimis ; involucri angusto-campanulati squamis 8-9 acuminatis ultra medium connatis ; ligulis ovalibus brevibus ; corollis disci tubo hirsutissimo, limbo sensim ampliato glabrato ; acheniis linearibus 5-gonis subglabris (exterioribus ad angulos hirtellis) nunc calvis nunc fere omnibus pappo brevi e paleis tenuibus eroso-truncatis coronatis. — Near Fort Tejon, Dr. Van Horn, in coll. Brewer. Nearly related to *L. (Monolopia, Benth.) bahiæfolia* of Hartweg's collection, which has a broader and more woolly involucre, disk-corollas with a narrower tube which is villous only in a ring at the junction with the broadly expanded limb, and hairy achenia, all, so far as known, destitute of pappus. In the present species the discovery of the pappus, conspicuous enough in some heads but wanting in others, confirms the suspicion that the *Monolopiæ* are epappose *Heleniæ*.

HULSEA ALGIDA : viscoso-villosula ; caule (spithamæo) folioso monocephalo ; foliis lineari-lingulatis aut repando- aut laciniato-dentatis sessilibus, imis subspathulatis, basibus dilatatis scariosis apicem caudicis crebre vestientibus ; capitulo maximo ; involucri squamis linearibus apice attenuatis albo-lanatis ; ligulis 50-60. — High peaks of the Sierra Nevada, on Mount Dana, at 11,500 feet, and Wood's Peak, 10,500 feet. Stems several from an ascending caudex, leafy nearly or quite to the head. Leaves $1\frac{1}{2}$ to 3 inches long, 3 to 6 lines wide. Head an inch in diameter. Achenia 3 to 4 lines long. Nearly related to *H. Californica*, of which I possess only a portion of an involucre (which is similar) and some flowers and achenia, the latter much smaller than in the present plant.

HULSEA VESTITA : caulibus abbreviatis e caudice subterraneo erecto folia conferta obovato-spathulata subintegerrima albo-tomentissima scapisque monocephalos gerentibus ; involucri squamis oblongo-linearibus viscoso-pubescentibus ; ligulis 20-30 ; pappi paleis conspicuis. — In dry volcanic ashes, near the summit of a volcanic hill south of Lake Mono, alt. about 9,000 feet. A remarkable species of this now well-established genus. Leaves thickly coated with matted white wool

(which may at length be deciduous?). broadly-spatulate or cuneate-obovate, one or two inches long, including the long-attenuate base or petiole. Scapes from 2 to 4 inches high, naked or with a few small linear bracts, viscous-pubescent, but entirely destitute of the white wool, as is the involucre also. Head about as large as that of *H. nana*, the involucre similar. The broad and truncate, eroded, silvery paleæ of the pappus are one fourth or nearly one third the length of the silky-villous achenia.

RIGIOPAPPUS, Nov. Gen. *Heleniearum*.

Capitulum pluriflorum, heterogamum; floribus radii 5–8 fœmineis, ligula parva discum vix superante; disci hermaphroditis, corolla tubulosa angusta 3–4-dentata, dentibus brevissimis. Involucrum biseriale, floribus brevius, e squamis subulato-linearibus rigidis foliis ramealibus conformibus. Receptaculum planum nudum. Styli rami fl. herm. parte stigmatosa brevi glabra (more *Asteroidearum*) complanata in appendicem gracilem subulatam hirtellam producta. Achenia gracilia, linearia, compressa, hispidula, transverse rugulosa. Pappus simplex, e paleis 4–5 rigidis subcorneis aristiformibus (angusto-subulatis corollam superantibus achenio ipso paullo brevioribus) constans. — Herba annua, gracilis, puberula; foliis alternis linearibus; ramis floriferis ex apice caulis simplicis paucis filiformibus monocephalis inferne aphyllis; floribus luteolis vel albidis?

RIGIOPAPPUS LEPTOCLADUS. — Dalles of the Columbia River, Oregon, Dr. Lyall, coll. Oregon Boundary Commission; communicated from the Herbarium of the Royal Gardens, Kew.

HEMIZONIA, DC., Torr. & Gray, § HEMIZONELLA.

Capitulum modo *Harpæcarpi* pauciflorum; floribus radii 4–5, ligula brevissima styli ramos haud superante, disci ad unicum raro duos intra cupulam 3–5 dentatam reducti. Achenia omnia perfecta; radii pl. m. obcompressa, subincurva. — Herbæ annuæ, tenellæ, foliis linearibus hirsutis fere eglandulosis. Acheniis exceptis ad *Harpæcarpum* referendæ.

HEMIZONIA (HEMIZONELLA) MINIMA: caule tenuissimo subpollicari 1–3-cephalo; foliis brevibus, summis capitula sessilia involucrantibus eaque vix superantibus; acheniis glabris, radii obovatis erostris. — Dry soil, near Soda Springs, alt. 8,680 feet. Leaves $1\frac{1}{2}$ to 2 lines

long, mostly opposite; the lower oval or oblong, minute. Doubtless this plant grows larger, but probably still remains different from the following species in its much obcompressed and broad achenia, the summit rounded and entirely destitute of any beak. Involucre, as in the other species, hispid-glandular on the back, completely enclosing the achenia.

HEMIZONIA (HEMIZONELLA) PARVULA: bi-tripollicaris, pilis albidis magis hispida; caule patentim ramoso; foliis angusto-linearibus, superioribus capitula sessilia involucrantibus eaque longe superantibus; acheniis glaberrimis angustis fusiformi-falcatis subtrigono-obcompressis, rostro brevi incurvo.— Klamath Valley, Oregon, Mr. Kronkite. Leaves half an inch to an inch long, half a line wide. It is this species which by the achenia most approaches the genus *Harpæcarpus*, but these are still decidedly obcompressed instead of compressed; and it would be very inconvenient now to admit compressed and obcompressed achenia into the same genus. Obviously these little plants are much reduced *Hemizonia*.

HEMIZONIA (HEMIZONELLA) DURANDI: caule a basi ramoso 3-6-pollicari; capitulis e dichotomiis plerisque pedunculatis folia fulcrantia adæquantibus; acheniis intus præsertim parce pilosis, floris centralis trigono apice truncato, radii obovato-oblongis trigono-obcompressis arcuatis, rostro brevi inflexo. (*Harpæcarpus madarioides*, Durand, Pl. Pratten. in Jour. Acad. Philad., non Nutt.)— Nevada County, California, Mr. Henry Pratten. Washoe County, Nevada, Mr. Stretch, communicated by Dr. Torrey.— Heads a line and a half in length, larger than in the foregoing species. I think this was also collected by Fremont, in his second expedition. But I possess no specimen of it.

WHITNEYA, Nov. Gen. *Heleniearum* v. *Senecionearum*, epapposum.

Capitulum multiflorum, heterogamum; floribus radii ligulatis fœmineis, disci tubulosis hermaphroditis. Involucrum biseriale, e squamis 10-12 æqualibus oblongo-lanceolatis acutis herbaceo-membranaceis. Receptaculum convexo-conicum, epaleatum, dense hirsutum. Ligulæ magnæ. Corollæ disci infundibuliformes, lobis breviusculis ovatis. Antheræ ecaudatæ. Stylus radii elongatus, disci ramis brevibus linearisubulatis complanatis obtusiusculis extus hirtellis. Achenia oblonga, obcompressa, calva.— Herba *Arnica* facie, montium Californiæ in-

cola; caule simplici e rhizomate gracili repente folisque oppositis tomento tenui argentatis; capitulo specioso; floribus aureis.

WHITNEYA DEALBATA. — Dry woods on the Yosemite trail, alt. 7,000 feet. Stem simple, a foot high, naked above, and bearing a single head, or with an additional monocephalous peduncle from the axil of the uppermost leaves. Leaves entire, mucronate; the radical or subradical ones obovate or oval, 3–5-nerved at the base, tapering into a flat or winged petiole; the cauline usually a single pair, smaller and narrower, sessile, and sometimes connate. Rarely there are two alternate bracts. Lateral peduncles, when they occur, usually bibracteate. Involucre half an inch long, equalling the disk, tomentulose. Tube of the corolla glandular-pubescent. Ligules over an inch long, lanceolate-oblong, 7–9-nerved, minutely three-toothed at the apex. Branches of the style in the disk-flowers tapering into a bluntish hairy apex, but not tipped with any distinct cone or appendage. Achenia hirsute-pubescent; those of the ray flat, 3-nerved on the inner face, and obscurely so on the outer face; those of the disk apparently similar and fertile, but immature in the three specimens collected. — This handsome Composita, doubtless belonging either to the *Senecioneæ* or *Heleniæ* (although destitute of pappus), is dedicated to the eminent Geologist in charge of the Californian State Survey, Professor Josiah D. Whitney, under whose superintendence a most interesting and extensive collection of dried plants of California, especially of the high sierras, has been made.

RAILLARDIA, Gaudichaud, § *RAILLARDELLA*.

Achenia magis compressa. Pappus niveus. Styli rami appendice tenuiori superati. Receptaculum planum seu convexum. — *Herbæ acaules, pumilæ, regionum alpinarum Californiæ montium incolæ, rhizomatibus subterraneis repentibus apice folia rosulata lanceolata subuninervia scapumque gracilem monocephalum proferentibus.*

RAILLARDIA (RAILLARDELLA) ARGENTEA: foliis spathulato-lanceolatis utrinque argenteo-sericeis; involucri cylindrico 7–15-floro cum scapo nudo glanduloso, squamis longe ultra medium coalitis; receptaculo plano glabro. — Sonora Pass, 8,000–10,000 feet, and Ebbett's Pass, at about the same altitude, on dry slopes. — Leaves one or two inches long, tapering into a short petiole, subcoriaceous; the silvery-silky pubescence perhaps somewhat deciduous with age. Scape $1\frac{1}{2}$ to

5 inches long, leafless and bractless. Involucre over half an inch in length, of 7–12 linear scales, which coalesce to near their acute tips, but are readily separable. Corolla light yellow. Branches of the style linear and gradually produced into a slender subulate appendage. Achenia linear, compressed, silky-pubescent, scarcely narrowed at the base. Bristles of the pappus softly plumose, bright white, nearly equaling the corolla.

RAILLARDIA (RAILLARDELLA) SCAPOSA: foliis subspathulato-linearibus ciliolatis cum scapo elongato inferne nunc 1–2-phyllis subviscosis; involucri cylindræco-campanulato 20–30-floro, squamis vix ultra medium coalitis; receptaculo convexo subpiloso. — On a peak of the Sierra Nevada, N. N. E. of Soda Springs, in sunny places, at an elevation of 10,000 feet. Leaves narrower and mostly longer than in the preceding species, $2\frac{1}{2}$ to 4 inches long, including the slender tapering base or petiole, wholly destitute of silvery pubescence, glabrous except a slight glandular pubescence along the margins, and viscid. Scape very slender, eight inches to a foot high. Head nearly an inch long. Receptacle showing somewhat of the hairiness and convexity of the genuine species of *Raillardia*.

These two species are, perhaps, the most interesting botanical discovery made by Professor Brewer. I had long since remarked that *Argyroxiphium* and *Wilkesia*, — very peculiar *Compositæ* of the Sandwich Islands, — represent there the *Madia* so characteristic of California and Oregon. We have here, in turn, two Californian plants so intimately allied to a most characteristic Hawaiian genus, *Raillardia* that, notwithstanding the difference in habit, I cannot venture to distinguish them generically.

ARTEMISIA POTENTILLOIDES: *Seriphidium*, undique incano-sericea, subpedalis; foliis radicalibus bipinnatisectis, caulinis plerisque pin-natipartitis, segmentis 3–11 linearibus nunc latiusculis; capitulis 3–6 hemisphæricis (majusculis) corymbosis; pedunculis gracilibus; involucri squamis, circa 10 æqualibus obovatis, marginibus hyalinis; receptaculo convexo hirsutissimo; floribus compluribus flavis. — Nevada, near Carson City, Dr. C. L. Anderson. — A most distinct species, with a tuft of simple ascending stems and bipinnately-divided silvery leaves from a thickish caudex; the cauline leaves few and small, an inch or less in length, the uppermost reduced to simple linear bracts. Heads 4 lines in diameter, depressed; the flowers all hermaphrodite and fertile.

CALAIS ERIOCARPHA: *C. cyclocarpæ* et *Bigelovii* similis; foliis *Taraxaci*; acheniis paullo gracilioribus acute costatis; pappi paleis (quandoque 3-4) ovalibus integerrimis extus lanatis arista sesquibrevioribus. — Nipoma, on low hills. The woolly paleæ of the pappus present a striking feature.

CALAIS APHANTOCARPHA: *C. Bigelovii* similis; acheniis paullo gracilioribus; pappi paleis 5 minimis deltoideis subito in aristam tenuem scabram achenio longior productis. — Bushy Knob, southeast of Monte Diablo. Leaves and scapes (one to two feet high) and the whole aspect not unlike *Leontodon autumnale*. Achenia of *Eucalais*, the outermost villous. Pappus of *Scorzonella*, the paleæ being reduced to a mere basal dilatation of the slender awn, but only five in number.

STEPHANOMERIA LACTUCINA: caule subsimplici e radice perenni tenuiter puberulo ad apicem usque æqualiter folioso oligocephalo; foliis lanceolatis seu linearibus parce spinuloso-dentatis vel integerrimis; capitulis subcorymbosis; involucri (semipollicaris) squamis lanceolatis subimbricatis; floribus circiter 10. — Dry hill near Big-tree Road in the Sierra Nevada, alt. 6,000 feet. A somewhat anomalous and large-flowered species of this genus, with the aspect rather of a reduced form of *Mulgedium pulchellum*. Stem not much branched. Leaves from $1\frac{1}{2}$ to $2\frac{1}{2}$ inches long, sessile, not clasping. Scales of the involucre somewhat broadly lanceolate, the outer ones of various lengths, and thus gradually passing into the inner ones, making the involucre somewhat imbricated. "Flowers delicate rose-color." Mature achenia not seen; but the ovaries wholly as in *Stephanomeria*. Pappus bright white, 4 or 5 lines long.

STEPHANOMERIA? CICHORACEA: tomento tenui mox evanido glabrata; caule rigido elato, ramis virgatis superne nudis racemoso-oligopolycephalis; foliis caulinis lanceolatis coriaceis rariter pinnatifido-dentatis vel denticulatis, dentibus spinescentibus; involucro circiter 12-floro e squamis plurimis lanceolatis gradatim imbricatis (exterioribus subsquarrosis) constante; receptaculo favoso; ligulis brevibus ut videtur roseis; acheniis lævibus; pappo sordido rigidulo breviter plumoso. — In the collection of Dr. Van Horn, from Fort Tejon, comm. to Professor Brewer. A plant of wholly doubtful genus, with the habit of *Cichorium Intybus*, but more leafy up the stems or branches; the leaves from 2 to 6 inches long, rigid, the larger ones furnished,

especially toward the base, with some coarse salient teeth. Flowers larger than in any genuine *Stephanomeria*; the involucre fully half an inch in length, of more rigid and imbricated scales than in that genus; the ligules about three lines long, scarcely exceeding the tube of anthers. Achenia, still young, short, truncate, costate, with wide intervals, not at all narrowed at the summit. Bristles of the pappus 15 to 20, uniserial, somewhat coalescent at the base, 3 lines long, equalling the tube of the corolla, barbellate-plumose after the manner of a *Liatris*. Plant apparently as much as three feet high; the base of the stem not seen.

CREPIS ANDERSONII: glaber (capitulis exceptis); caudice perenni folia oblongo-spathulata vel oblongo-lanceolata laciniato-pinnatifida seu dentata subruncinata scaposque corymboso-ramosos proferente, ramis monocephalis; involucre glanduloso-pubero vel glabrato 2-3-seriali, squamis lanceolatis, interioribus attenuato-acuminatis discum fructiferum adæquantibus; acheniis fusiformibus sensim brevi-rostratis angulato-pluricostatis. — Nevada, in the vicinity of Carson City, chiefly in low grounds. Leaves 2 to 5 inches long, including the tapering base or petiole, sometimes only denticulate or dentate, sometimes pinnatifid and with the lobes lacinate-toothed. Scapes from 10 to 24 inches high, angled and strongly striate, usually leafless and with a few linear bracts. Heads three fourths of an inch in length, or sometimes smaller; the involucre more imbricated than in *C. occidentalis* and *C. runcinata*. Flowers golden yellow. Achenia about 3 lines long, smooth, angled with salient ribs and deep furrows. Pappus soft and white.

HIERACIUM BREWERI: humilis (triuncialis ad subpedalem); foliis uniformibus oblongo-spathulatis integerrimis cum caule usque ad apicem folioso pilis longis mollibus albo-villosissimis; panicula corymbosa polycephala; capitulis parvis 10-15-floris; involucre subimbricato cylindræo vix glanduloso cum pedicellis parce piloso; floribus flavis; acheniis oblongo-linearibus haud apice vix basi angustatis. — Silver Valley in the Sierra Nevada, alt. 7,350 feet, and (a dwarfed alpine state) Silver Mountain, alt. 11,000 feet. Somewhat resembling the most hairy forms of *H. Scouleri*, Hook.; but dwarf, very leafy to the top, and canescent with very soft shaggy hairs, except the inflorescence; the latter of very numerous heads in a crowded panicle. Involucre 3 lines long.

To the account of these new *Compositæ* of Western North America I append the characters of a striking new genus belonging to the Sandwich Islands, recently discovered by Mr. Horace Mann.

HESPEROMANNIA. Nov. Gen. *Mutisiacearum*.

Capitulum homogamum, multi- et æqualiflorum, discoideum, floribus hermaphròditis. Involucrum campanulato-turbinatum, multiseriale; squamis chartaceo-rigidis obsolete nervatis, mucronato-acutis, interioribus lineari-lanceolatis, exterioribus sensim brevioribus. Receptaculum planum nudum. Corollæ subcoriaceæ, angustæ, subregularis (leviter bilabiata, 3, extus intusque glabræ, tubo 5-nervi), laciniis longis linearibus erectis. Filamenta imo tubo corollæ inserta, e fauce exserta: antheræ lineares, brevissime caudatæ, caudis truncatis ultra articulum haud productis. Stylus filiformis, ramis brevissimis angustis acutiusculis. Achenium oblongo-lineare, angulatum, erostre, glabrum. Pappus multiserialis, setis rigidulis scabris. — Arbuscula inermis, glaber; foliis obovato-oblongis subserratis penninerviis breviter petiolatis ad apices ramorum brevium confertis; capitulis terminalibus subumbellatis brevi-pedunculatis ea *Chuquiragæ insignis* æmulantibus; floribus flavis.

HESPEROMANNIA ARBORESCENS. — On the highest part of Lanai, one of the Sandwich or Hawaiian Islands; coll. Horace Mann and W. T. Brigham.

This is specially interesting as being the only known *Labiatiflora* from any of the proper Pacific Islands. These *Compositæ*, so characteristic of South America, appear to be wanting even in Juan Fernandez. As the present plant does not fall into any published genus, it would appropriately bear the name of its discoverer, Mr. Horace Mann, the latest and one of the most ardent explorers of the botany of the Sandwich Islands, who has gleaned not a few novelties in a field which has been harvested by numerous botanists, from Nelson and Menzies, in the times of Cook and Vancouver, down to Remy in 1851 – 1853. The name of *Mannia*, however, having been already bestowed upon a genus of *Simarubæ*, in commemoration of the arduous botanical services of Mr. Gustavus Mann in Tropical Africa, I venture, in the generic appellation here proposed in compliment to our Western young botanist of the same name, to compound the word by a distinguishing prefix.

The genus belongs to the *Flotowia*, according to Weddell's neat arrangement: and agrees with *Chuquiraga* and *Doniophyton* in having the long filaments free from the corolla down almost to its base. But the merely scabrous copious pappus, and naked and glabrous receptacle, as well as the corolla glabrous within, and the achenia, wholly separate it from these andine genera. On the other hand, it quite as much resembles the Brazilian and Cuban *Stiftia* and *Anastraphia*; but in the latter of these genera the filaments are adnate almost, and in the former quite, to the sinuses of the corolla; while the anthers in both of them are long-tailed, and the lobes of the corolla more or less revolute.*

Two well-marked new Ferns, which the explorations of the California State Geological Survey have brought to light, are characterized by Professor Eaton as follows:—

PELLÆA BREWERI, *D. C. Eaton* (sp. nov.): caudice brevi assurgente; stipitibus bi-tripollicaribus confertis fulvo-nitentibus teretibus fragillimis basi paleis angustissimis fulvis obtectis; frondibus tri-quadrupollicaribus oblongis pinnatis, pinnis brevi-petiolatis membranaceis pellucidis plerumque bipartitis, segmento superiori majore, segmentis pinnisque superioribus ovatis vel triangulari-ovatis basi cuneatis, venis liberis pluries furcatis; sporangiis ad apices venularum paucis indusio continuo tenui revolutis velatis.—*Rupestris* inter montes *Sierra Nevada* Californiæ, altitudine 7,000–9,000 ped. super mare. Prof. W. H. Brewer, n. 1919, 2102, 2038.

ASPIDIUM (POLYSTICHUM) CALIFORNICUM, *D. C. Eaton* (sp. nov.): elatum, insignè; frondibus oblongo-lanceolatis pinnatis, pinnis confertis lanceolatis falcatis acutissimis basi superiori auriculatis, imis vix minoribus, inferioribus pinnatifidis, mediis pinnatilobatis, supremis gradatim minoribus spinuloso-serratis, lobis ovato-oblongis spinuloso-apiculatis subtus paleis angustis conspersis supra glabris, venis pinnatis liberis, pinnis fere omnibus soriferis; soris confertis; indusiis teneribus orbiculatis ciliatis pedicello brevi gracili suffultis; rhachi stipiteque paleis difformibus instructis aliis magnis lato-lanceolatis aliis minoribus

* In *Stiftia chrysantha* I do not find the tube of the corolla 10-nerved, nor the branches of the style acute; the latter are rather spatulate and very obtuse.

anguste linearibus ciliatis. — In montibus Californiæ prope *Santa Cruz*, H. N. Bolander. Frons fere bipedalis, 5–6 poll. lata. Stipes pedalis et ultra. E grege *A. lobati*, sed aspectu et elegantia *A. munitum* referens.

INDEX TO VOL. VI.

A.

Achromatic object-glass, 169.
 Actinolepis multicaulis, 546.
 Achyropappus Woodhousei, 546.
 AGASSIZ, A., Communication from, 495.
 On Embryology of Asteracanthion berylinus, 106.
 AGASSIZ, PROF. L., Communication from, 81.
 ALGER, FRANCIS, Obituary Notice of, 294.
 Amendments to Statutes, 294.
 Ampelichnus sulcatus, 86.
 Analysis, New methods of, 251, 472.
 Anisopus gracilior, 86.
 Anomœpus intermedius, 85.
 minimus, 85.
 Apatichnus curvatus, 86.
 Aplopappus Bloomeri, 541.
 Macronema, 542.
 suffruticosus, 542.
 APPLETON, NATHAN, Obituary Notice of, 1.
 Arabis platysperma, 519.
 Artemisia potentilloides, 551.
 Arthonia cyrtodes, 285.
 Aspidium Californicum, 555.
 Associate Fellows elected, 23, 24, 96, 176, 238, 241, 390, 517.
 Asteracanthion berylinus, 111.
 pallidus, 112.
 Aster Bloomeri, 539.
 Astragalus aboriginum, 203.
 adsurgens, 197.
 alpinus, 205.
 Americanus, 205.
 Andersonii, 524.
 aridus, 223.

Astragalus Arthu-Schottii, 209.
 Beckwithii, 221.
 Bigelovii, 196.
 bisculatus, 221.
 Bourgovii, 227.
 Brazoensis, 198.
 Breweri, 207.
 cæspitosus, 230.
 campestris, 229.
 Canadensis, 196.
 caryocarpus, 192.
 chaetodon, 194.
 Chamælence, 222.
 Cobrensis, 199.
 collinus, 225.
 Cooperi, 213.
 Coulteri, 233.
 Crotalariae, 216.
 curtipes, 217.
 cyrtoides, 201, 525.
 decumbens, 229.
 diaphanus, 233.
 didymocarpus, 198.
 diphysus, 193.
 distortus, 207.
 diversifolius, 230.
 Douglasii, 215.
 Drummondii, 200.
 Fendleri, 224.
 filifolius, 215.
 filipes, 226.
 flavus, 201.
 flexuosus, 224.
 Fremontii, 194.
 frigidus, 219.
 Geyeri, 214.
 glaber, 208.
 glabriusculus, 204.
 gracilentus, 223.
 gracilis, 202.

Astragalus glareosus, 211.
Hallii, 224.
Hartwegi, 199.
Hookerianus, 215.
humistratus, 201.
hypoglottis, 197.
ineptus, 525.
junceus, 230.
Kentrophyta, 231.
lentiginosus, 194, 524.
leptaleus, 220.
leptocarpus, 200.
leucophyllus, 218.
leucopsis, 217.
Lindheimeri, 207.
lonchocarpus, 219.
lotiflorus, 208.
Lyalli, 195.
macrodon, 216.
megacarpus, 215.
Mexicanus, 193.
Menziesii, 217.
microcystis, 220.
miser, 228.
Missouriensis, 210.
mollissimus, 196.
Mortoni, 196.
multiflorus, 226.
nothoxys, 232.
Nuttallianus, 199.
obcordatus, 208.
oocarpus, 213.
Oreganus, 202.
oroboides, 205.
oxyphysus, 218.
Palliseri, 227.
Parryi, 211.
pauciflorus, 228.
pectinatus, 221.
pictus, 214.
Plattensis, 193.
platytropis, 526.
Preussii, 222.
pubentissimus, 209.
Purshii, 212.
pycnostachius, 527.
racemosus, 200.
reflexus, 197.
Robbinsii, 204.
sclerocarpus, 225.

Astragalus sericoleucus, 232.
serotinus, 229.
Shortianus, 210.
simplicifolius, 231.
Sonoræ, 223.
sparsiflorus, 205.
speirocarpus, 225.
stenophyllus, 226.
succumbens, 200.
tener, 206, 525.
Tennesseeensis, 193.
tephrodes, 222.
Thurberi, 220.
trichopodus, 218.
tridactylicus, 527.
triflorus, 214.
triphyllus, 232.
uliginosus, 196.
Utahensis, 213.
vaccarum, 199.
villosus, 208.
Whitneyi, 526.
Wrightii, 199.

B.

BALDWIN, JAMES F., Obituary Notice of, 129.
 BARLOW, PETER, Obituary Notice of, 15.
 BARTLETT, WILLIAM P. G., Obituary Notice of, 498.
 Baryta, Aluminates of, 97.
 BECK, DR. CHARLES, Communication from, 106.
 BELL, LUTHER V., Obituary Notice of, 5.
Bifurculapes curvatus, 87.
 BIGELOW, JACOB, Reports, 27, 32, 34, 83, 472.
 BIOT, JEAN BAPTISTE, Obituary Notice of, 16.
Bisculus undulatus, 86.
 Blowpipe beads, 476.
 BOND, PROF. G. P., Achromatic Object-Glass, 169.
 A List of New Nebulæ, 177.
 Obituary Notice of, 499.
 BOOTT, FRANCIS, Obituary Notice of, 305.

BOWDITCH, J. I., Report of, 356.
 BRODIE, SIR BENJAMIN COLLINS,
 Obituary Notice of, 139.
 Brontozoum isodaetylum, 86.
 Burrielia leptalea, 546.

C.

Calais aphantocarpha, 552.
 eriocarpha, 552.
 Calamagrostis Aleutica, 80.
 Canadensis, 77.
 confinis, 79.
 deschampsoides, 80.
 Langsdorffii, 77.
 Lapponica, 78.
 Nuttalliana, 79.
 Pickeringii, 80.
 Porteri, 79.
 stricta, 78.
 strigosa, 78.
 sylvatica, 80.
 Calceolaria bartsiaefolia, 49.
 calycina, 49.
 petiolaris, 49.
 CALDERON, ANGEL DE LA BARCA,
 Obituary Notice of, 12.
 Chænaetis tanacetifolia, 545.
 Xantiana, 545.
 CHILD, PROF. F. J., Communica-
 tion from, 26.
 Chrysopsis Bolanderi, 543.
 Breweri, 542.
 CLARK, ALVAN, Communication
 from, 97.
 CLARK, H. J., On the Animal Na-
 ture of Cilio-flagellate Infu-
 soria, 393.
 Communication from, 96.
 Cleomella parviflora, 520.
 Clerodendron Amicorum, 50.
 inermis, 50.
 ovalifolium, 50.
 Collema leptaleum, 263.
 Conditional Sentences, 363.
 COOKE, PROF. J. P., Communica-
 tions from, 182, 495.
 Crepis Andersonii, 553.
 Crustacean Tracks, 88.
 Cymopterus cinerarius, 535.

Cymopterus fœniculaceus, 536.
 Nevadensis, 536.
 Cyrtandra anthropophagorum, 41.
 biflora, 37.
 dolichocarpa, 40.
 induta, 38.
 involuta, 41.
 labiosa, 40.
 Milnei, 40.
 pogonantha, 40.
 Pritchardi, 41.
 pulchella, 38.
 Richii, 39.
 Samöensis, 39.
 Taitensis, 39.

D.

DEAN, DR., Communications from,
 237, 262.
 Demosthenes, Note on, 330.
 DEXTER, W. P., Alumniates of
 Baryta, 97.
 Communication from, 96.
 Draba eurycarpa, 520.

E.

ELIOT, SAMUEL A., Obituary No-
 tice of, 2.
 EMERSON, G. H., Crystals and
 Precipitates in Blow-pipe
 Beads, 476.
 Epilobium obcordatum, 532.
 Erigeron Andersonii, 540.
 Bloomeri, 540.
 Breweri, 541.
 concinnum, 540.
 Erythræa sabæoides, 41.
 Euchardium Breweri, 532.
 EVERETT, EDWARD, Obituary No-
 tice of, 500.
 Exocampe minimus, 86.

F.

Fellows elected, 23, 81, 96, 176,
 238, 241, 321, 390, 517.

- Fellows and Foreign Honorary Members, list of, 323.
- Felspar, Green, 167.
- FELTON, C. C., Obituary Notice of, 7.
- FERREL, WILLIAM, Influence of the Tides, 379.
communication from, 390.
- FOLSOM, CHARLES, Communication from, 106.
- Foreign Honorary Members elected, 23, 96, 97, 176, 241, 363.
- FRANCIS, J. B., On the Strength of Cast Iron Pillars, 403.
- G.
- Galium Andrewsii, 537.
Bloomeri, 538.
hypotríchium, 538.
- Gaura angustifolia, 352.
biennis, 351.
coccinea, 352.
Drummondii, 353.
filipes, 353.
Lindheimeri, 351.
longiflora, 351.
macrocarpa, 353.
parviflora, 354.
sinuata, 353.
suffulta, 352.
tripelata, 352.
villosa, 353.
- GILLISS, JAMES M., Obituary Notice of, 506.
- GOODWIN, PROF. W. W., Conditional Sentences, 363.
Note on Demosthenes, 329.
Note on Thucydides, 330.
- GOULD, DR. B. A., Communications from, 81, 92, 105.
Report, 240.
- GRAHAM, COL. J. D., Communication from, 354.
- Grallator parallelus, 86.
- Grammichnus Alpha, 86.
- GRAY, PROF. ASA, Characters of New Plants from California and Nevada, 519.
- GRAY, PROF. ASA, Characters of Monopetalous Plants in collection of U. S. South Pacific Exploring Expedition, 37.
A Revision of the N. American Species of Astragalus and Oxytropis, 188.
A Revision of the N. American Species of Calamagrostis, 77.
Synopsis of Genus Pentstemon, 56.
Note on Rhytidandra, 55.
On Streptanthus, 182.
- GREENE, BENJ. D., Obituary Notice of, 132.
- GRIMM, JACOB, Obituary Notice of, 314.
- Gyalecta carneo-luteola, 271.
- H.
- HALE, NATHAN, Obituary Notice of, 131.
- Harpedactylus crassus, 86.
gracilior, 86.
- Harpepus capillaris, 87.
- HAYWARD, GEORGE, Obituary Notice of, 296.
- Helianthus Bolanderi, 544.
exilis, 545.
- Hemizonia (Hemizonella) Durandi, 549.
minima, 548.
parvula, 549.
- Hesperomannia arborescens, 554.
- Heterogaura Californica, 355.
- Hieracium Breweri, 553.
- HILL, DR. T., Communication from, 84.
- HITCHCOCK, PROF. E., Communication from, 104.
Ichthyology of New England, 85.
Obituary Notice of, 291.
- Horkelia Californica, 529.
capitata, 529.
congesta, 529.
fusca, 529.

- Horkelia parviflora*, 529.
 tenuiloba, 529.
 tridentata, 530.
 HUBBARD, J. S., Obituary Notice
 of, 300.
Hulsea algida, 547.
 vestita, 547.
 HUNT, EDWARD B., Obituary No-
 tice of, 301.

I.

- Ichnology of New England, 85.
 Infusoria, 393.
 Insanity among women, 241.
 Insect tracks, 87.
Ivesia Gordoni, 530.
 lycopodioides, 530.
 Pickeringii, 531.
 pygmaea, 531.
 santolinoides, 531.

J.

- JACKSON, DR. C. T., Communica-
 tions from, 81, 166.

K.

- Kellogia galioides*, 539.

L.

- Lasthenia ambigua*, 547.
Lecanora Bolanderi, 266.
 Frostii, 267.
 Haydeni, 267.
 pinguis, 268.
 subflava, 267.
Lecidea aureola, 281.
 chlororhpnia, 275.
 furfurosa, 274.
 leptocheila, 280.
 leucocheila, 278.
 luteo-rufula, 276.
 medialis, 280.
 microphyllinia, 278.
 oncodes, 274.
 orphnæa, 274.
 pachycheila, 281.

- Lecidea palmicola*, 277.
 parasema, 282.
 parvifolia, 272.
 pellæa, 276.
 polycampia, 274.
 thysanota, 277.
 turbinata, 282.
 vulpina, 281.
 Wrightii, 275.
 Letters received, 1, 26, 34, 81, 84,
 95, 96, 105, 106, 127, 148,
 166, 168, 237, 262, 290,
 347, 362, 379, 383, 472,
 497.
 Library, Donations to, by
 Académie des Sciences de l'In-
 stitut Impériale de France,
 152, 337.
 Academy, Royal Irish, 152.
 Academy, Royal Leopold
 Charles, Dutch, 156.
 Academy of Sciences, Royal
 Swedish, 342.
 Agassiz, A., 162.
 Agassiz, L., 162, 343.
 Alger, Francis, 160.
 American Assoc. for Advanc.
 of Science, 335.
 American Journal of Science
 and Arts, Editors, 165, 334.
 Amsterdam, Royal Acad. of
 Sciences of, 157.
 Augsburg, Nat. Hist. Soc. of,
 156.
 Austrian Government, 154.
 Bacon, John, 162.
 Basel, Nat. Hist. Soc. of, 154.
 Batavian Nat. Hist. Soc., 157,
 343.
 Batavian Soc. of Arts and Sci-
 ences, 157.
 Beck, Charles, 343.
 Berlin, Royal Prussian Acad-
 emy of Sciences of, 154, 338.
 Berne, Nat. Hist. Soc. of, 153,
 340.
 Bianconi, G. Giuseppe, 165.
 Bonn, University of, 154, 338.
 Bordeaux, Imperial Academy
 of Sciences of, 153.

Library, Donations to by,

- Boston Public Library, 149.
- Boston Soc. of Nat. Hist., 149, 333.
- British Assoc. for Advanc. Science, 151, 336.
- British Government, 336.
- Brooks, Rev. Charles, 164.
- Brünn, Nat. Hist. Soc. of, 338.
- Brussels, Royal Acad. of Sciences, 155, 340.
- Brussels, Royal Observatory, 156, 341.
- Bryant, Henry, 343.
- Cadiz, Observatory at, 159.
- Caen, Imperial Academy of Sciences, 150, 335.
- Californian Acad. Nat. Sciences, 150, 335.
- Cambridge, Observatory at, 149, 333.
- Cambridge, Museum of Comp. Zool., 333.
- Cherbourg, Imperial Soc. of Nat. Sciences, 153.
- Chevrenl, M. E., 153.
- Christiana, Royal University, 158, 341.
- Cincinnati, Young Men's Mercantile Libr. Assoc., 166, 335.
- Clinton, George W., 345.
- Congress, Library of, 334.
- Copenhagen, Royal Danish Acad., 341.
- Dana, James D., 164.
- Dantzic, Soc. of Naturalists, 338,
- Darmstadt, Geological Soc., 156, 338.
- Dawson, J. W., 161, 345.
- Dean, John, 345.
- Desnoyers, M. J., 346.
- De Zingo, Achille, 163.
- Dijon, Imperial Acad. of Sciences, 153, 337.
- Dresden, Nat. Hist. Soc., 157.
- Dresden, Royal Institution for the Blind, 338.
- Dublin, Geological Soc., 337.

Library, Donations to, by

- Dublin Royal Society, 152, 337.
- Elliott, E. B., 164.
- Emden, Nat. Hist. Soc., 156, 338.
- Essex Institute, 149, 334.
- Flugel, Felix, 162.
- Folsom, Charles, 166, 343.
- Frankfort on M., Zoölog. Soc., 157, 338.
- Frankfort on M., Soc. of Arts, 157.
- Freiburg, Nat. Hist. Soc., 156, 338.
- Fries, Elias, 165.
- Geissen, Upper Hessian Soc. Nat. Hist., 338.
- Geneva, Soc. Physics and Nat. Hist., 153.
- Görlitz, Upper Hessian Soc., 156, 338.
- Göttingen, Royal Soc. of Sciences, 155, 340.
- Gould, B. A., 163.
- Great Britain, Royal Institution of, 151, 336.
- Haarlem, Dutch Academy of Sciences, 157, 341.
- Hale, James, 344.
- Hale, Hon. John P., 164.
- Halle, Nat. Hist. Soc., 156, 338.
- Hansteen, Prof. C., 347.
- Haughton, Rev. Samuel, 345.
- Hubbard, O. P., 343.
- India, Government of, 152, 337.
- Institution, Meteorological, of the Netherlands, 341.
- Jarvis, Edward, 161, 344.
- Jewett, Charles C., 344.
- Kneeland, S., 162.
- Kölliker, Albert, 164.
- Königsberg, Royal Observatory at, 156.
- Königsberg, Royal Physical and Economical Society, 156, 339.
- Lea, Isaac, 163, 304.

- Library, Donations to, by
 Leipzig, Jablonowskian Society of, 155.
 Leipzig, Royal Soc. of Sciences of, 155, 339.
 Lisbon, Royal Acad. of Sciences of, 158, 342.
 Liverpool, Lit. and Phil. Soc., 152, 337.
 Logan, Sir William, 345.
 London, Chemical Soc. of, 336.
 London, Geological Soc. of, 151, 336.
 London, Horticultural Soc. of, 151, 336.
 London, Lords' Commiss. of the Admiralty, 152.
 London, Linnæan Soc. of, 335.
 London, Royal Soc. of, 150, 335.
 London, Statistical Soc. of, 151, 336.
 London, Zoölogical Soc. of, 336.
 Loring, Hon. Charles G., 164, 344.
 Lüneburg, Soc. of Physical Sciences of, 339.
 Luxembourg, Soc. of Natural Sciences of Grand Duchy of, 339.
 Lyons, Imp. Acad. of Sciences, Belles-Lettres, and Arts of, 337.
 Macfarlane, Thomas, 161.
 Madrid, Royal Acad. of Sciences of, 159.
 Maine et Loire, Academic Soc. of, 153.
 Manchester, City Council of, 152.
 Manchester, Lit. and Phil. Soc. of, 151.
 Marcou, Jules, 161.
 Martius, C. F. Ph. von, 346.
 Massachusetts, Commonwealth of, 166.
 Massachusetts Hist. Soc., 149.
 Montreal, Nat. Hist. Soc. of, 152.
- Library, Donations to, by
 Moscow, Imperial Soc. of Naturalists of, 158, 341.
 Munich, Royal Acad. of Sciences of, 155, 339.
 Naples, Royal Soc. of, 342.
 Nassau, Soc. of Nat. Sciences in Grand Duchy of, 157.
 Normandy, Linnæan Soc. of, 153.
 New York, Lyceum of Nat. Hist. of, 150, 333.
 New York, Mercantile Lib. Assoc. of, 334.
 Nürnberg, Nat. Hist. Soc. of, 339.
 Offenbach, Nat. Hist. Soc. of, 339.
 Parker, Henry T., 165.
 Paris, Geographical Soc. of, 153, 337.
 Paris, Museum of Nat. Hist. of, 153.
 Peters, C. H. F., 161.
 Philadelphia College of Pharmacy, 150, 334.
 Philadelphia, Acad. of Nat. Sciences of, 150, 334.
 Poole, William F., 344.
 Portland Soc. of Nat. Hist., 149.
 Prague, Royal Observatory of, 156, 340.
 Prague, Royal Soc. of Sciences of, 156.
 Quebec, Lit. and Hist. Soc. of, 335.
 Quetelet, A., 346.
 Radcliffe Trustees, 151, 337.
 Reader, Editors of, 346.
 Regel, Dr. E., 160.
 Regensburg, Zoölog. and Mineralog. Soc. of, 156, 340.
 Rhineland and Westphalia (Prussian), Nat. Hist. Soc. of, 154.
 Rouen, Imperial Acad. of Sciences, &c. of, 153.
 Russia, Administration of Mines of, 157.

Library, Donations to, by
 Saussure, Henri de, 165, 347.
 Schaufuss, L. W., 346.
 Schlechtendal, Dr. L. F. von,
 346.
 Scrope, G. Poulett, 159.
 Sibley, J. L., 165.
 Smithsonian Institution, 150,
 334.
 Society, American Antiqua-
 rian, 149, 334.
 Society, American Oriental,
 149, 334.
 Society, American Philosoph-
 ical, 150, 334.
 Society of Arts, Manufactures,
 and Commerce, 151, 336.
 Society, Imperial Zoölog. of
 Acclimation, 153, 337.
 Society, Royal Astronomical,
 336.
 Society, Swiss, of Naturalists,
 340.
 Society, Swiss, of Nat. Sci-
 ences, 340.
 St. Gall, Soc. of Physical Sci-
 ences, 154.
 St. Louis, Acad. of Sciences,
 150.
 St. Louis, Mercantile Library
 Assoc., 166.
 St. Petersburg, Imperial Acad.
 of Sciences, 157, 341.
 St. Petersburg, Royal Min-
 eralogical Soc., 159.
 Stettin, Entomological Soc. of,
 156, 340.
 Strasbourg, Soc. of Nat. Sci-
 ences, 153.
 Storrow, Charles S., 166.
 Sumner, Hon. Chas., 159, 344.
 Swett, Col. Samuel, 344.
 Ticknor, George, 343.
 Turin, Royal Acad. of Sci-
 ences of, 342.
 Tyneside Naturalists' Field
 Club, 151, 337.
 U. S. Naval Observatory, 150.
 Upsal, Royal Soc. of Sciences
 of, 158, 342.

Library, Donations to, by
 Whitney, J. D., 162.
 Whitney, Prof. William D.,
 164, 343.
 Wien, Royal Acad. of Sci-
 ences, 154, 340.
 Wien, Royal Geographical
 Soc., 340.
 Wien, Royal Geological Soc.,
 154, 340.
 Wien, Royal Zool. and Bo-
 tanical Soc., 154, 340.
 Williams, Henry D., 160.
 Wilson, Hon. Henry, 165.
 Winkler, T. C., 347.
 Winlock, Prof. Joseph, 344.
 Wolf, Dr. Rudolf, 163.
 Zeuner, Dr. Gustav, 163.
Limnanthemum Kleinianum, 42.*
Linosyris Howardii, 541.
Linum Breweri, 521.
 Californicum, 521.
 congestum, 521.
 Hesperolinon, 521.
Lippia seriphioides, 49.
Lithophragma affinis, 534.
 Bolanderi, 535.
 Cymbalaria, 535.
 glabra, 533.
 heterophylla, 535.
 parviflora, 534.
 tenella, 534.
Lonicera Breweri, 537.
 LOVERING, Prof. J.,
 On the Velocity of Light and
 Sun's Distance, 114.
 Reports, 168, 238, 320, 495,
 516.
 LOWELL, J. A., Report, 262.
Lunar Bolis, 36.
Lunula obscura, 86.
Lupinus meionanthus, 522.
Lycium Sandwicense, 44.

M.

Machaeranthera Shastensis, 539.
 Meteoric Iron, 166.
 MITCHEL, O. M., Obituary Notice
 of, 133.

Mitella Breweri, 533.
 MITSCHERLICH, EILHARD, Obitu-
 ary Notice of, 310.
 MORLEY, E. W., Communication
 from, 384.
Myroporum Sandwicense, &c., 52.

N.

Nebulæ, List of New, 177.
Nesogenes euphrasoides, 51.
Nothocestrum breviflorum, 49.
 latifolium, 48.
 longifolium, 48.

O.

Officers, Election of, 24, 141, 322,
 356.
 OLIVER, J. E., Communication
 from, 288.
Opegrapha microcycilia, 285.
Oxytropis campestris, 235.
 deflexa, 236.
 Lamberti, 236.
 multiceps, 234.
 nana, 236.
 podocarpa, 234.
 splendens, 236.
 Uralensis, 235.

P.

PALGRAVE, SIR FRANCIS, Obitu-
 ary Notice of, 13.
 PARSONS, PROF. T., Communica-
 tions from, 105, 472.
 PEIRCE, PROF. B., Communica-
 tions from, 84, 96, 97, 114,
 128, 169.
 On the Lunar Bolis, 36.
Pentacœlium, 52.
Pellæa Breweri, 555.
Pentstemon acuminatus, 61.
 albidus, 67.
 alpinus, 60.
 ambiguus, 64.
 antirrhinoides, 57.
 attenuatus, 72.
 azureus, 75.
 baccharifolius, 58.

Pentstemon barbatus, 59.
 breviflorus, 57.
 cæruleo-purpureus, 72.
 cæruleus, 61.
 cæspitosus, 66.
 campanulatus, 74.
 centranthifolius, 63.
 Cobæa, 68.
 confertus, 72.
 cordifolius, 58.
 corymbosus, 58.
 cristatus, 67.
 cygnanthus, 60.
 dasyphyllus, 65.
 deustus, 73.
 diffusus, 74.
 Digitalis, 68.
 dissectus, 64.
 Douglasii, 57.
 Fremonti, 60.
 frutescens, 76.
 Gairdneri, 65.
 gentianoides, 63.
 glaber, 59.
 glandulosus, 74.
 glaucus, 70.
 gracilis, 69.
 gracilentus, 75.
 grandiflorus, 62.
 Hallii, 70.
 Harbourii, 71.
 Hartwegi, 64.
 heterander, 73.
 heterophyllus, 75.
 humilis, 69.
 imberbis, 59.
 Jamesii, 67.
 lætus, 76.
 lanceolatus, 65.
 laricifolius, 64.
 Lewisii, 56.
 linarioides, 66.
 Menziesii, 56, 76.
 microphyllus, 57.
 multiflorus, 68.
 Murrayanus, 62.
 Newberryi, 57.
 occidentalis, 60.
 ovatus, 71.
 perfoliatus, 74.

Pentstemon pubescens, 69.
 pumilus, 67.
 puniceus, 63.
 Richardsonii, 74.
 Scouleri, 57.
 spectabilis, 63.
 stenophyllus, 65.
 stenopetalus, 70.
 strictus, 60.
 tenuifolius, 64.
 ternatus, 58.
 Thurberi, 65.
 Torreyi, 59.
 triphyllus, 75.
 tubiflorus, 68.
 venustus, 74.
 virgatus, 66.
 Whippleanus, 73.
 Wislizeni, 59.
 Wrightii, 63.
Phaca, 192, 212.
 debilis, 233.
 panifolia, 233.
 PICKERING, DR., Communication from, 360.
 Pillars, Cast Iron, Strength of, 403.
 PLANA, BARON GIOVANNI, Obituary Notice of, 308.
Placodium campitidium, 287.
 cladodes, 265.
 coralloides, 287.
 diphasium, 287.
 erythranthrum, 287.
 Floridanum, 287.
 phæum, 266.
Plantago Hawaiensis, 54.
 hirtella, 54.
 Kavaiensis, 55.
 laxiflora, 54.
 Maviensis, 54.
 Orbignyana, 53.
 pachyphylla, 54.
 pauciflora, 53.
 princeps, 54.
 uncialis, 54.
 Polar and Clock Stars, Catalogue of, 35.
 Pole Star, 242, 356.
Polycellium, 52.
Pugiopappus Bigelovii, 545.

Q.

QUINCY, JOSIAH, Obituary Notice of, 504.

R.

Raillardia (*kaillardella*) *argentea*, 550.
 scaposa, 551.
 RENWICK, JAMES, Obituary Notice of, 134.
 Report of the Committee on Publication, 24, 141, 320, 356, 516.
 Report of the Council, 1, 128, 175, 290, 498.
 Report of the Library Committee, 24, 148, 333, 516.
 Report, Treasurer's Annual, 24, 141, 319, 516.
Rhytidandra, Note on, 55.
Rigiopappus leptocladus, 548.
 RITCHIE, E. S., Communication from, 104.
 ROBINSON, EDWARD, Obituary Notice of, 136.
 ROGERS, PROF. WILLIAM B., Communication from, 128.
 ROSE, HEINRICH, Obituary Notice of, 312.
 ROTHROCK, J. T., Synopsis of North American *Gaurineæ*, 347.
 Rumford Committee, Reports, 238, 495, 516.
 Rumford Fund, 24, 27, 34, 84, 164, 238.
 Rumford Premium, 26, 495, 497, 516.

S.

SAFFORD, T. H., Communications from, 35, 93, 96, 262, 472.
 On Observed Motions of the Companion of Sirius, 143.
 On the Right Ascension of the Pole Star, 242.
Saxifraga bryophora, 533.
Scalichnus incertus, 87.
 SHORT, CHARLES W., Obituary Notice of, 135.

- SILLIMAN, BENJAMIN, Obituary Notice of, 509.
 Smelowskia Californica, 520.
 Solanum Amicorum, 44.
 inamœnum, 44.
 incompletum, 43.
 Kavaïense, 43.
 Nelsoni, 42.
 repandum, 44.
 Sandwicense, 43.
 viride, 44.
 Solidago Guiradonis, 543.
 Spectroscope, 182.
 Sphenosciadium capitellatum, 537.
 Stephanomeria cichoracea, 552.
 lactucina, 552.
 Stereocaulon pilophoroides, 265.
 Streptanthus bracteatus, 183.
 Breweri, 184.
 carinatus, 183.
 cordatus, 183.
 crassicaulis, 186.
 flavescens, 186.
 glandulosus, 185.
 heterophyllus, 185.
 hispidus, 186.
 maculatus, 183.
 platycarpus, 183.
 polygaloides, 519.
 procerus, 519.
 repandus, 186.
 tortuosus, 184.
 STORER, DR. H. R., Communication from, 241.
 STRUVE, FRIEDRICH GEORG WILHEIM, Obituary Notice of, 514.
 SULLIVAN, RICHARD, Obituary Notice of, 4.
 Sulphur, Analysis of, 472.
 Sun's distance, 114.
- T.
- Tetrathyranthus, 50.
 Thelotrema catastictum, 270.
 latilabrum, 269.
 leucastrum, 269.
 lirelliforme, 270.
 platycarpoides, 270.
 simplex, 271.
 Thelypodium brachycarpum, 520.
 Thucydides, Note on, 329.
 Tides, Influence of, 354, 379.
 TOTTEN, JOSEPH G., Obituary Notice of, 303.
 Trachylia Californica, 263.
 TREADWELL, PROF. DANIEL, Communications from, 127, 262, 402.
 Trifolium amplexens, 523.
 Andersonii, 522.
 bifidum, 522.
 monanthum, 523.
 Trihamus elegans, 86.
 Trisculeus laqueatus, 86.
 TUCKERMAN, EDWARD, Observations on North American Lichens, 263.
- U.
- Urceolaria choroleuca, 268.
- V.
- Velocity of light, 114.
 Verrucaria Drummondii, 286.
- W.
- WARE, JOHN, Obituary Notice of, 298.
 WARREN, C. M., Communication from, 361.
 On a Process of Organic Elementary Analysis, 251.
 On a Process for determining Sulphur in Organic Compounds, 472.
 WASHBURN, PROF. EMORY, Communication from, 106.
 WHATELY, RICHARD, Obituary Notice of, 317.
 Whitneya dealbata, 550.
 WHITNEY, PROF., Communications from, 383, 472.
 WINLOCK, PROF. J., Communications from, 114, 356.
 Wyethia glabra, 543.
 mollis, 544.
 WYMAN, PROF. J., Communication from, 238.

Fig. 1.

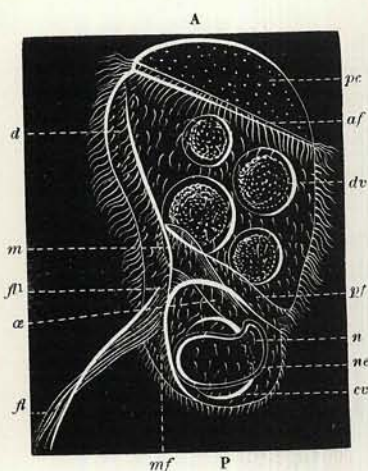


Fig. 2.

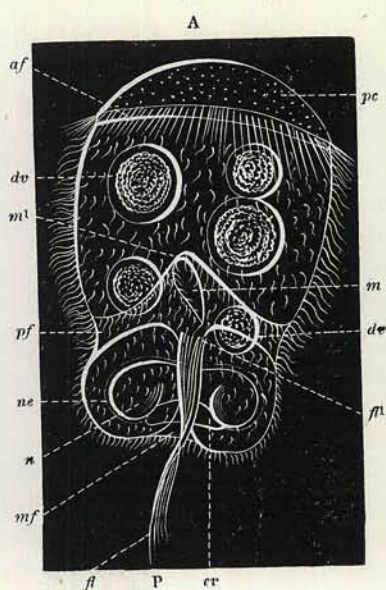


Fig. 3.

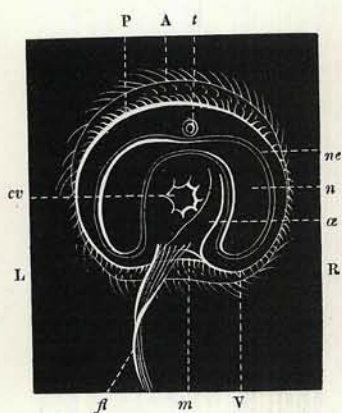


Fig. 4.

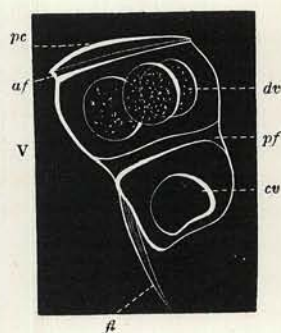


Fig. 5.

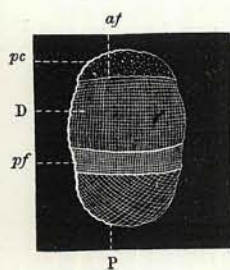


Fig. 7.

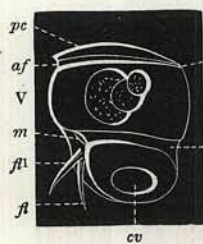
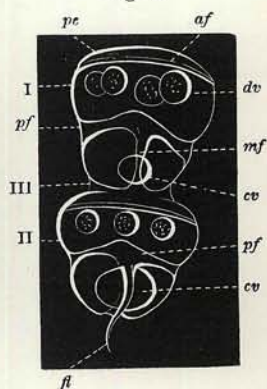


Fig. 6.



[To face page 401.]

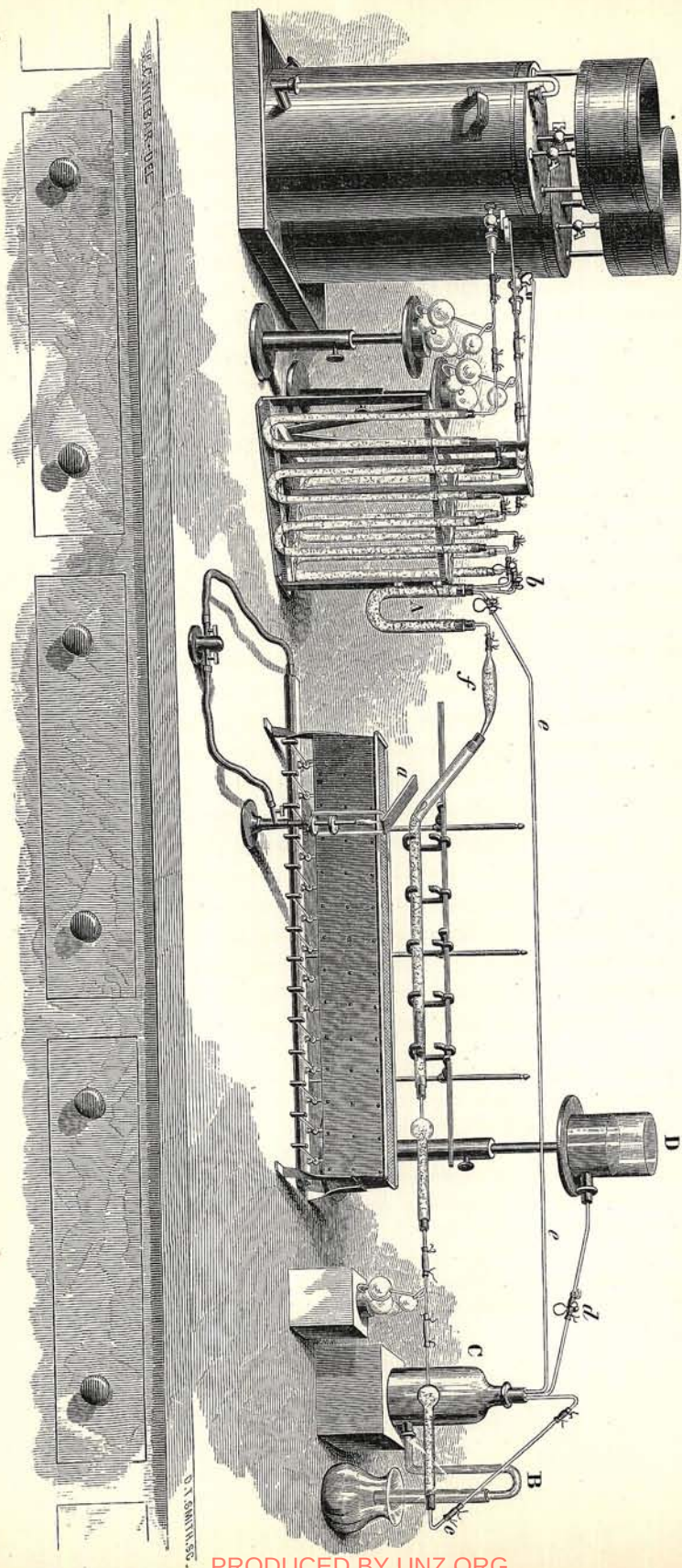


Fig. 1.



Fig. 2.



Fig. 3.

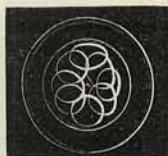


Fig. 4.



Fig. 7.

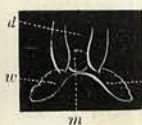


Fig. 8.



Fig. 6.

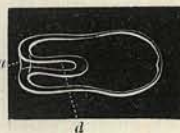


Fig. 5.



Fig. 9.

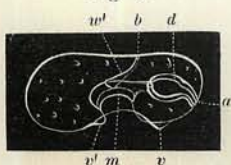


Fig. 10.



Fig. 11.

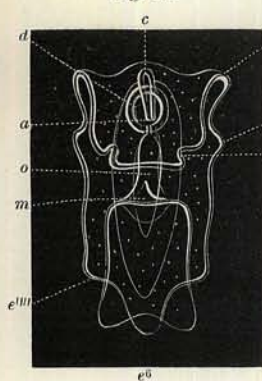


Fig. 12.

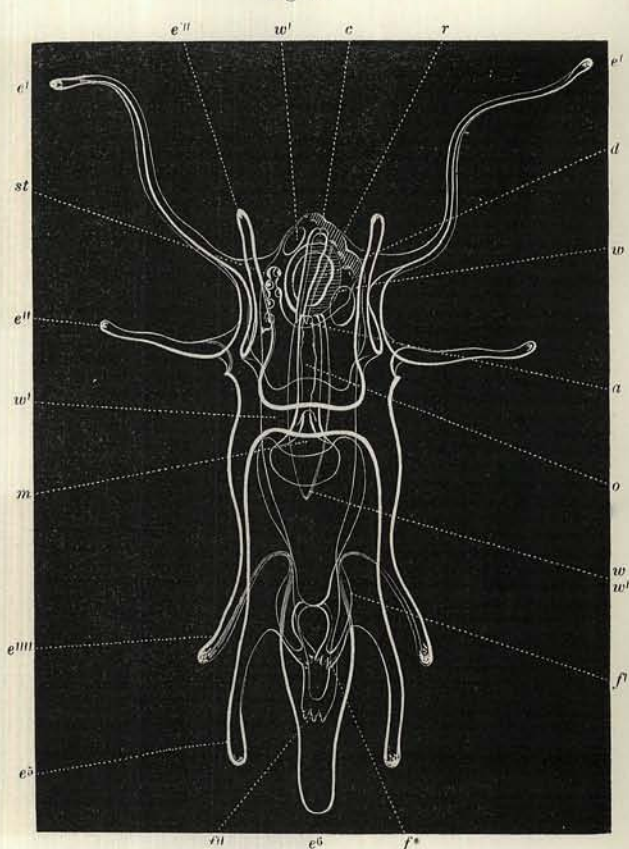


Fig. 16.

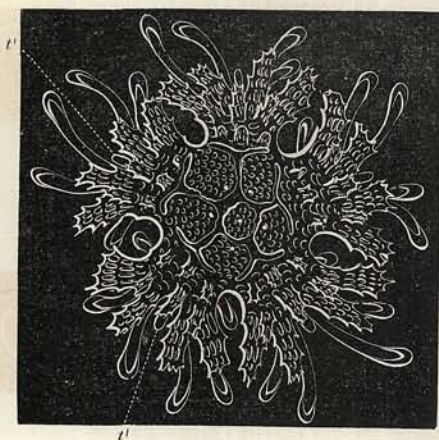


Fig. 14.



Fig. 15.



Fig. 18.



Fig. 17.

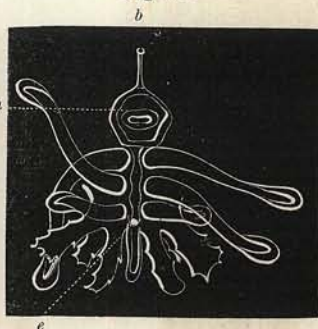
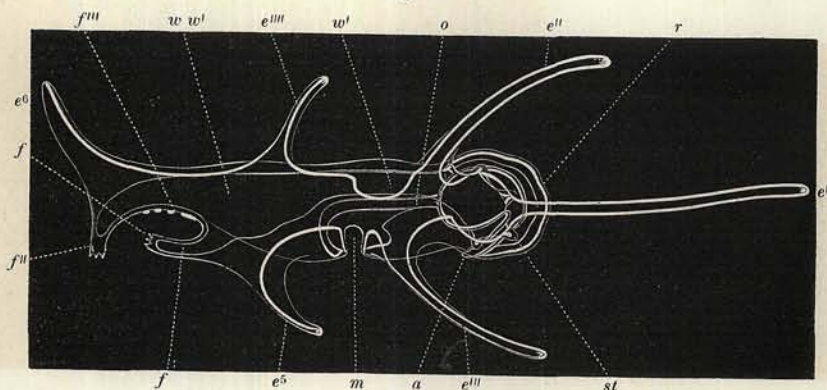
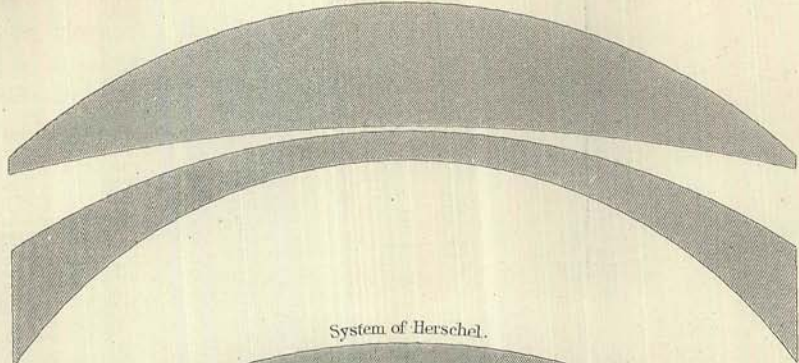


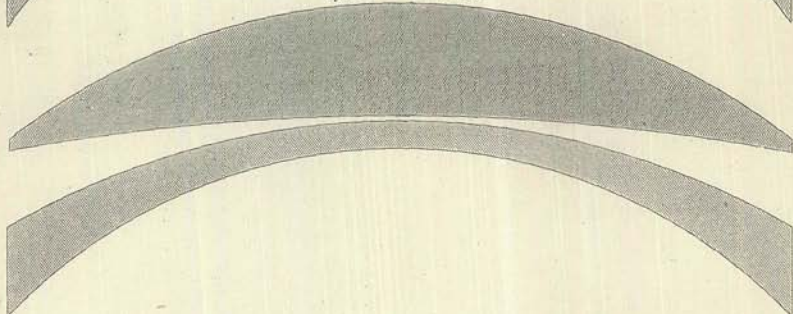
Fig. 13.



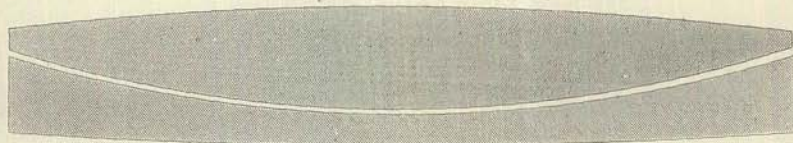
System of Gauss.



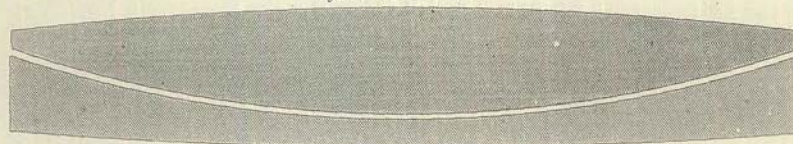
System of Herschel.



System of Fraunhofer.



System of Herschel.



CURVES OF ACHROMATIC OBJECT GLASSES.